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MISSOURI STATE WATER PLAN SERIES

VOLUME IV

Water Use of Missouri

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Division of Geology and Land Survey

Missouri State Water Plan Series Volume IV

Water Use of Missouri

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PREFACE

MISSOURI STATE WATER PLAN TECHNICAL VOLUME SERIES

The Missouri Department of Natural Resources State Water Plan Technical Volume Series is part of a comprehensive state water resource plan. This portion is designed to provide basic scientific and background information on the water resources of the state. The information in these technical volumes will provide a firm foundation for addressing present and future water resource needs and issues. Each volume in the series deals with a specific water resource component.

Volume I

The ***Surface Water Resources of Missouri*** contains a basin-by-basin assessment of Missouri's surface water resources. It discusses the effects of climate, geology and other factors on the hydrologic characteristics of major lakes, streams and rivers. It also assesses surface-water availability and development in the state.

Volume II

The ***Groundwater Resources of Missouri*** presents information on the availability and natural quality of groundwater throughout the state. It focuses on Missouri's seven groundwater provinces and includes their geology, hydrogeology, areal extent, general water quality, and potential for contamination. Aquifer storage estimates are given for each aquifer and county. The report also reviews the different types of water-supply wells in use and how water well construction techniques vary between areas and aquifers.

Volume III

Missouri Water Quality Assessment focuses on the current quality of Missouri surface water and ground-water. The volume looks at chemical, bacteriological and radiological water-quality, and natural and man-induced water-quality changes.

Volume IV

The ***Water Use of Missouri*** describes how Missouri is presently using its surface-water and groundwater resources. The report covers private and public water supplies, industrial and agricultural water uses, and water use for electrical power production, navigation, recreation, fish and wildlife.

Volume V

Hydrologic Extremes in Missouri: Flood and Drought provides basic information about flooding and drought specific to Missouri. A historical perspective is given, as well as information that can be used in planning for hydrologic extremes. It also describes concepts and defines terminology helpful in understanding flood and drought.

Volume VI

Water Resource Sharing - The Realities of Interstate Rivers presents Missouri's views concerning interstate rivers. Because of its location, Missouri can be greatly affected by activities and water policy in the upper basin states of the Missouri and Mississippi river basins. Missouri policy can also affect downstream states on the Mississippi, Arkansas and White rivers. Many serious issues affecting these rivers have less to do with their physical characteristics than with political, economic and social trends.

Volume VII

Missouri Water Law provides an overview of the laws that affect the protection and use of Missouri's water resources. It supplies reference information about existing doctrines, statutes and case law.

COVER:
Children immersed in water use at Lake of the Ozarks—Public Beach No. 1. Photo by Nick Decker.

EXECUTIVE SUMMARY

Much of Missouri's water use remains undocumented. It could be said that we use all water in the state, even if it is only to behold its beauty. In 1993 (the latest water use data available at the time of this writing), total documented water use in Missouri exceeded 8.65 trillion gallons, which was enough to fill the Lake of the Ozarks 13 times. Electrical generation used 8.2 trillion gallons of water in 1993, a somewhat misleading figure. Electrical generation requires a large amount of water, but consumes very little. Missouri's thermo-electric generation facilities "used" more than 1.9 trillion gallons of water in the 1993 calendar year, but actually consumed only 15 billion gallons. Hydroelectric power plants in Missouri used 6.3 trillion gallons of water to produce electricity that year but, by definition, consumed none of it.

Municipal water users in Missouri reported withdrawing 233.3 billion gallons of water in 1993. Although comparatively small, the quantity of water withdrawn by municipal users is second only to the amount used to produce electricity. Municipal water use is reported in nearly every county of the state, but the St. Louis and Kansas City metropolitan areas account for more than two-thirds of the statewide total. Water users in the domestic category (household and subsistence use) reported withdrawals of 15.6 billion gallons of water in 1993. Water users in the industrial category reported using nearly 23.5 billion gallons of water in creating marketable products.

Missouri's industrial users were not the only ones using water to produce goods in 1993. Irrigators in this state used almost 148 billion gallons of water to improve yields of corn, soybeans, rice, and many other crops. More than 95 percent of that water was applied to the fertile, lowland plains of the Bootheel. Farmers were also using water to support their livestock, withdrawing an estimated 17 billion gallons of water to water stock and process livestock products in 1992.

We also "use" water in Missouri without actually withdrawing it. A major use of the Missouri and Mississippi rivers is that of transporting commodities in river barges. In 1992, 29 million tons of commodities were either shipped from or received at port facilities in Missouri. Water use by hydroelectric power plants, although reported as electrical generation water use, is also commonly considered an in-stream flow use because it does not withdraw water to produce electricity.

Water-based recreation is another important "in-stream" use of Missouri's water resources. The 1990 Missouri State Comprehensive Outdoor Recreation Plan found that, in the previous year, Missourians spent 133.6 million activity-days engaging in outdoor water-based recreation.

How we manage our water greatly impacts its suitability to support fish and wildlife. In some cases, habitat preservation is critical—40 aquatic animal species are listed as "endangered" in Missouri.

INTRODUCTION

Water is used in a myriad of ways in Missouri. Each of these ways are important. In fact, the old saying "beauty is in the eye of the beholder," could be modified to say, "the importance of water is in the eye of the user." In meeting Missouri's various water requirements, it is vital that we understand the nature of each use. It is not enough to know how much water is used, we must also understand how water is used. This will leave us better prepared for the long range task of assessing our future water needs, be they complimentary or conflicting.

As a riparian water rights state, we have not kept the detailed records or made the scientific measurements necessary to accurately monitor our water use. The water use estimates provided in this report rely upon information available from a variety of public and private sources. This report, as a result, is not intended to be the final word on water use in Missouri, but rather a first step towards improving our knowledge of Missouri's use of water through better data collection and analysis techniques.

Water Use in Missouri is a survey of the many ways Missourians put their surface and groundwater reserves to use. It seeks to provide a foundation for understanding water use by introducing basic water use concepts and terminology. Water use categories covered in the report include: water use in thermoelectric and hydroelectric power generation; municipal, domestic and industrial water use; agricultural water use; in-stream water use issues (such as navigation and aquatic habitat preservation); water use in recreation; and water use for fish and wildlife.

The report draws from the Department of Natural Resources' Major Water Users Database and the USGS National Water-Use Information Program. For some uses, water use information is not collected and the report relies on other techniques to depict usage. For example, although the Major Water Users Database does not include livestock water use data, it can be estimated using agricultural census data and water use coefficients. For other uses, so little information exists on the quantity of water used that estimates of usage are unavailable. These uses are described, but quantification will require further study. One example is in-stream flows needed to maintain fish populations. Methodologies exist to estimate this water use, but very few stream reaches in Missouri have been studied.

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PUBLIC WATER SUPPLY OF MISSOURI

INTRODUCTION

Unlike other water uses, water supply issues affect every citizen of Missouri. Whether our water is obtained from a public water supply source or private well, high quality water is essential to both our health and lifestyle. Because water supplies are so important to us, protecting water quality is crucial. As water passes through the environment, it can be made unsafe and unusable in many ways. For example, urban runoff and leaky landfills can introduce metals and harmful chemical compounds to surface water supplies. As byproducts of decomposition and waste, bacteria are pervasive in surface waters and groundwater supplies near the surface. As a result, endless opportunities exist for fresh water to become contaminated.

Fortunately, it is possible to remove most contaminants from our water supplies. Through the efforts of Missouri's public water suppliers, we are able to enjoy a safe, reliable supply of drinking water at a reasonable cost. Suppliers not only provide treatment, they also take steps (such as implementing strict monitoring and training programs) to ensure a continuing supply of high-quality drinking water.

Most Missourians obtain their public water from municipalities and public water supply districts. Chapters 71 and 91 of the Missouri Revised Statutes authorize municipalities to construct and operate water supply facilities; they may also contract with other municipalities or corporations (both public and private) to obtain water for their citizens.

In an effort to extend the benefits of public water supply to rural areas, the Missouri General Assembly authorized the formation of public water supply districts through Chapter 247 of the Missouri Revised Statutes. The regulations governing public water supply districts, as noted in the Missouri Revised Statutes, are "intended to make possible, through public corporations, conveniences in the use of water, ample in quantity for all needful purposes and pure and wholesome in quality, furnished from common sources of supply to many inhabitants of our state now denied such privileges; and thereby promote public health and sanitation, make available conveniences not otherwise possible, and for the general public welfare." Although the statutes governing municipal water supplies leave the aforementioned aspiration unsaid, the intent is nonetheless the same.

The water supplies that we use each day are allocated among a variety of uses. These uses meet residential and domestic needs such as drinking, washing and watering; industrial and commercial needs such as demands by factories and hospitals; and public needs such as firefighting (figure 1). Although most of the water used to support these needs is taken from public water supplies, a substantial portion of Missourians rely on private, self-supplied water. According to U.S. Geological Survey Circular 1081, "Estimated Use of Water in the United States in 1990," one million of Missouri's 5.1 million citizens obtained water from private supplies in that year. Missourians not using water from public supplies depend upon private wells (or other sources, such as cisterns), which usually meet only household water requirements.

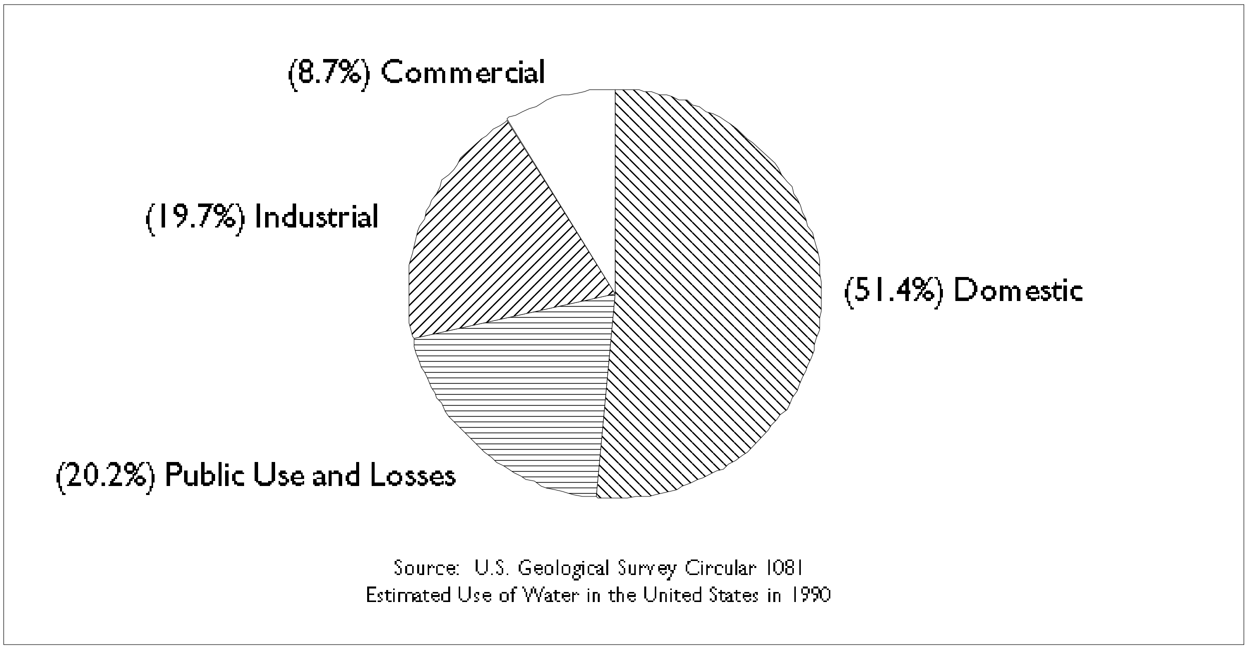


Figure 1. Usage of public water supply deliveries in Missouri, 1990.

DEFINITIONS OF WATER SUPPLY

The Missouri Department of Natural Resources does not define "water supply" as a broad category of water use. Rather, water supply in Missouri is covered within three separate, yet related, categories—municipal water use, domestic water use, and industrial water use. Together, these three categories encompass a wide variety of public and private water uses. Complete definitions for each of these categories can be found in this report.

Some overlap exists among these categories. For example, many public water supplies reporting use in the "municipal" category provide water to both industrial and domestic water users within their service areas. Some municipal water suppliers estimate household water use and report it under the "domestic" category; others include household water use in the "municipal" category. Water extracted under domestic, municipal and industrial categories may come from a public supply or be self-supplied. Because of these inconsistencies, reported water use in the DNR domestic, municipal and industrial categories does not truly reflect overall water use by domestic, municipal and industrial users.

SOURCES OF WATER SUPPLY

The most common sources of water in Missouri are groundwater wells. Missouri groundwater comes primarily from two sources—bedrock aquifers and shallower alluvial aquifers. Collectively, these sources serve the majority of Missourians in some way. Most public water supply facilities currently operating in Missouri rely to some extent on groundwater wells as a source of water supply. Similarly, most self-supplied residential, commercial and industrial water withdrawals are extracted from groundwater sources.

Figure 2 shows the distribution of public water wells in Missouri. Figure 3 shows the distribution of surface water intakes statewide. In terms of sheer volume, surface water sources provide the bulk of water withdrawals statewide (figure 4). In 1990, freshwater surface water withdrawals in the state were estimated at 493 million gallons daily, compared to 185 million gallons per day from groundwater sources. The vast majority of these withdrawals come from the Missouri River, which is by far the single most important source of water in the state for all water supply needs. The Missouri River provides most of the drinking water for

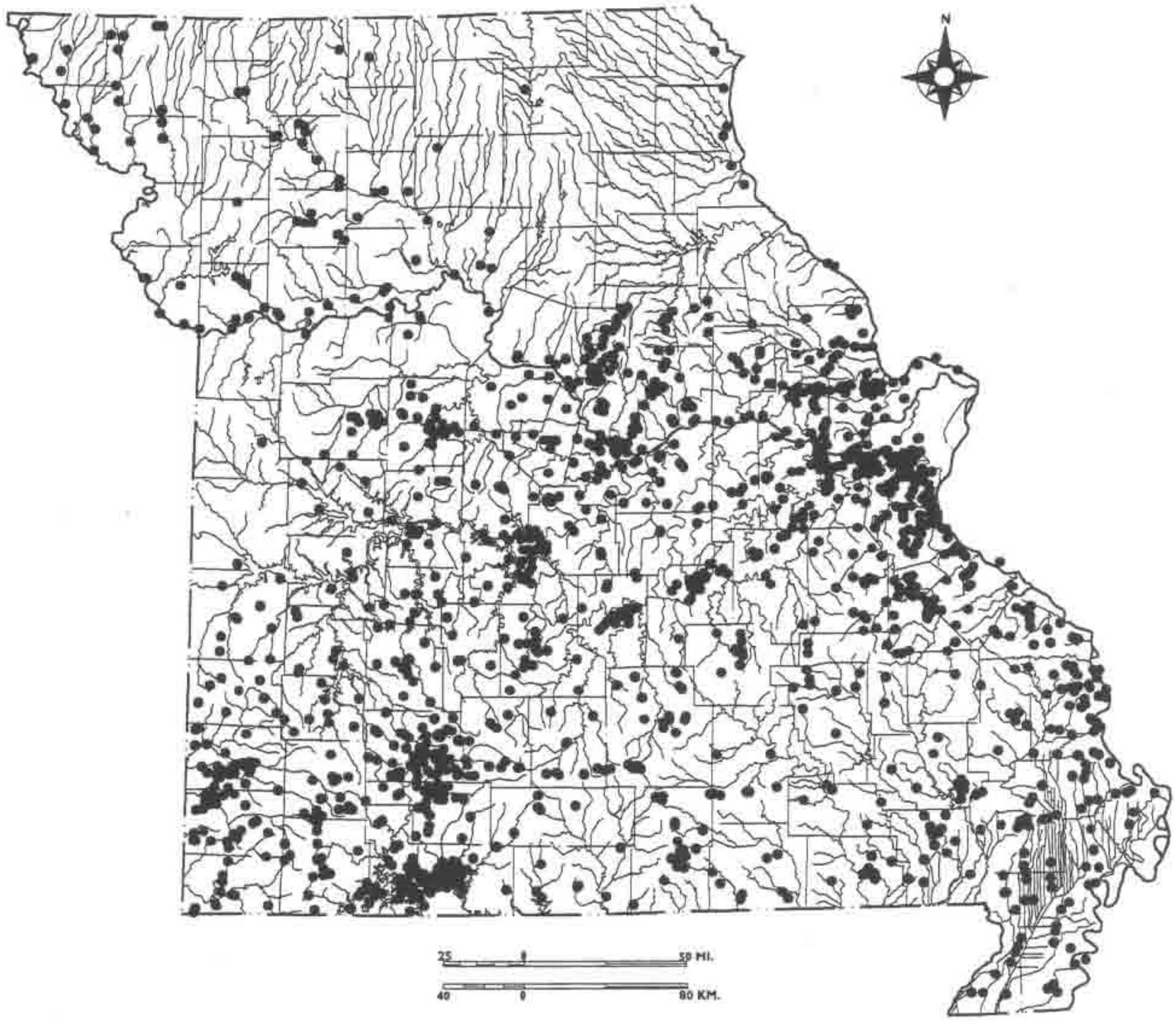


Figure 2. Locations of public water supply wells in Missouri, 1996.

metropolitan Kansas City and St. Louis, as well as the river communities of St. Joseph, Lexington, Glasgow, Boonville and Jefferson City. In fact, the Missouri River alone provides water to slightly less than half of the publicly-supplied population of the state (figure 5).

More than 500,000 Missourians rely upon other surface water sources (large and small water supply reservoirs and lesser rivers in the state) for their water needs. Much of Missouri's water supply volume is held in man-made reservoirs. Although many of the state's larger reservoirs (such as Truman Reservoir or Mark Twain Lake) serve some water supply purposes, a substantial segment of the population uses much smaller lakes constructed specifically to meet local water needs. Sufficient water supplies from these locations are readily available

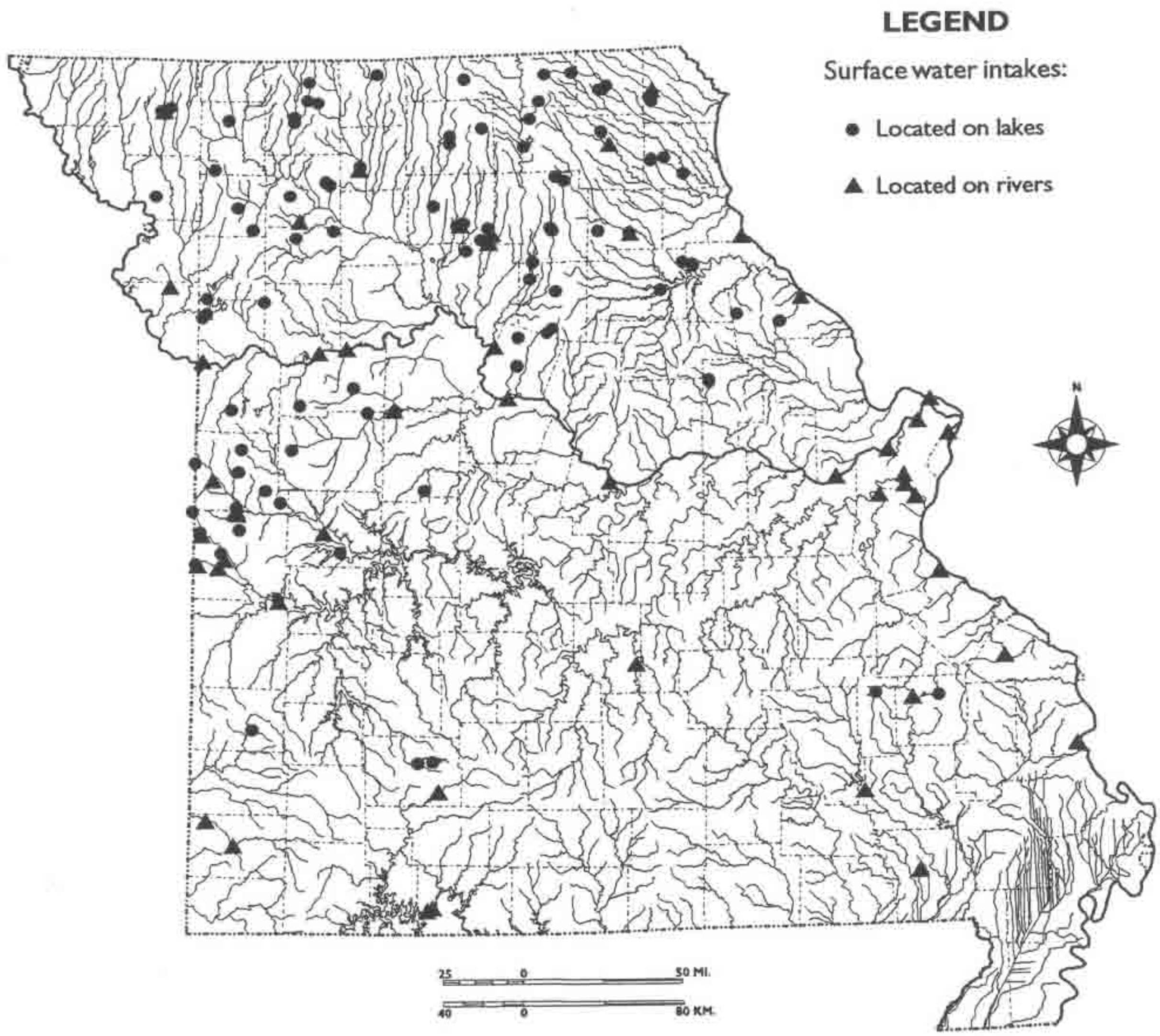


Figure 3. Locations of public water supply surface water intakes in Missouri, 1996

for local public water supply districts and municipalities. The availability of water in Missouri, while generally reliable, can be a problem during periods of extended drought, and as a result, maintenance of distribution networks is important to all users and critical when water reserves are low.

Residential Water Use

Residential water use is typically defined as water used for household purposes, such as water for drinking, cooking, bathing, home maintenance and recreation. The Department of Natural Resources' Major Water Users Database expands this definition to include live-

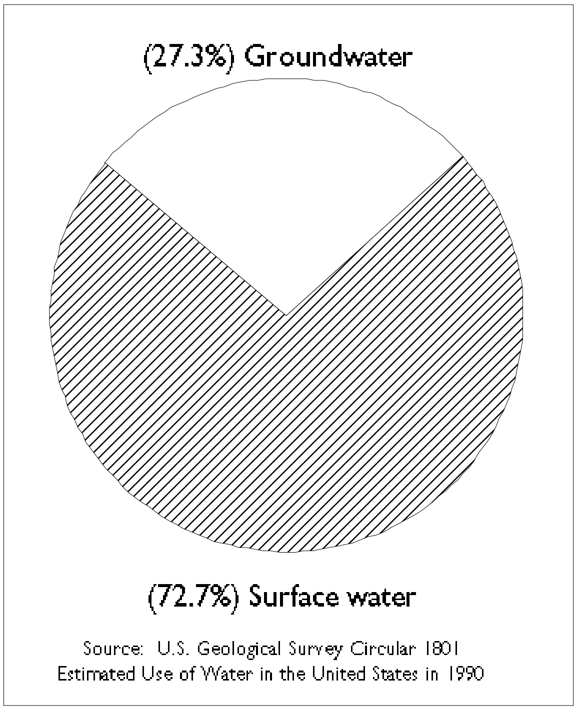


Figure 4. Sources of water used for public water supply in Missouri, 1990

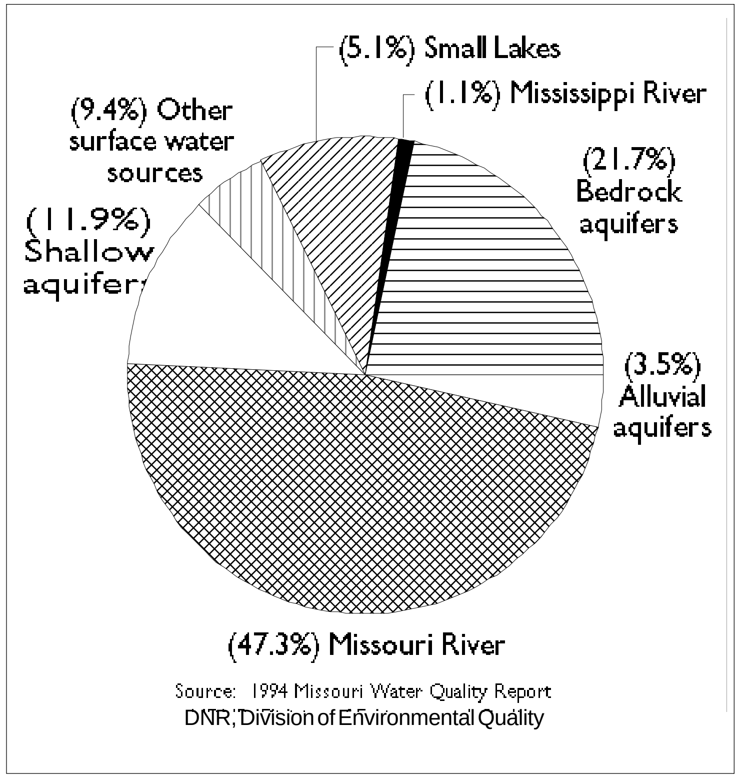
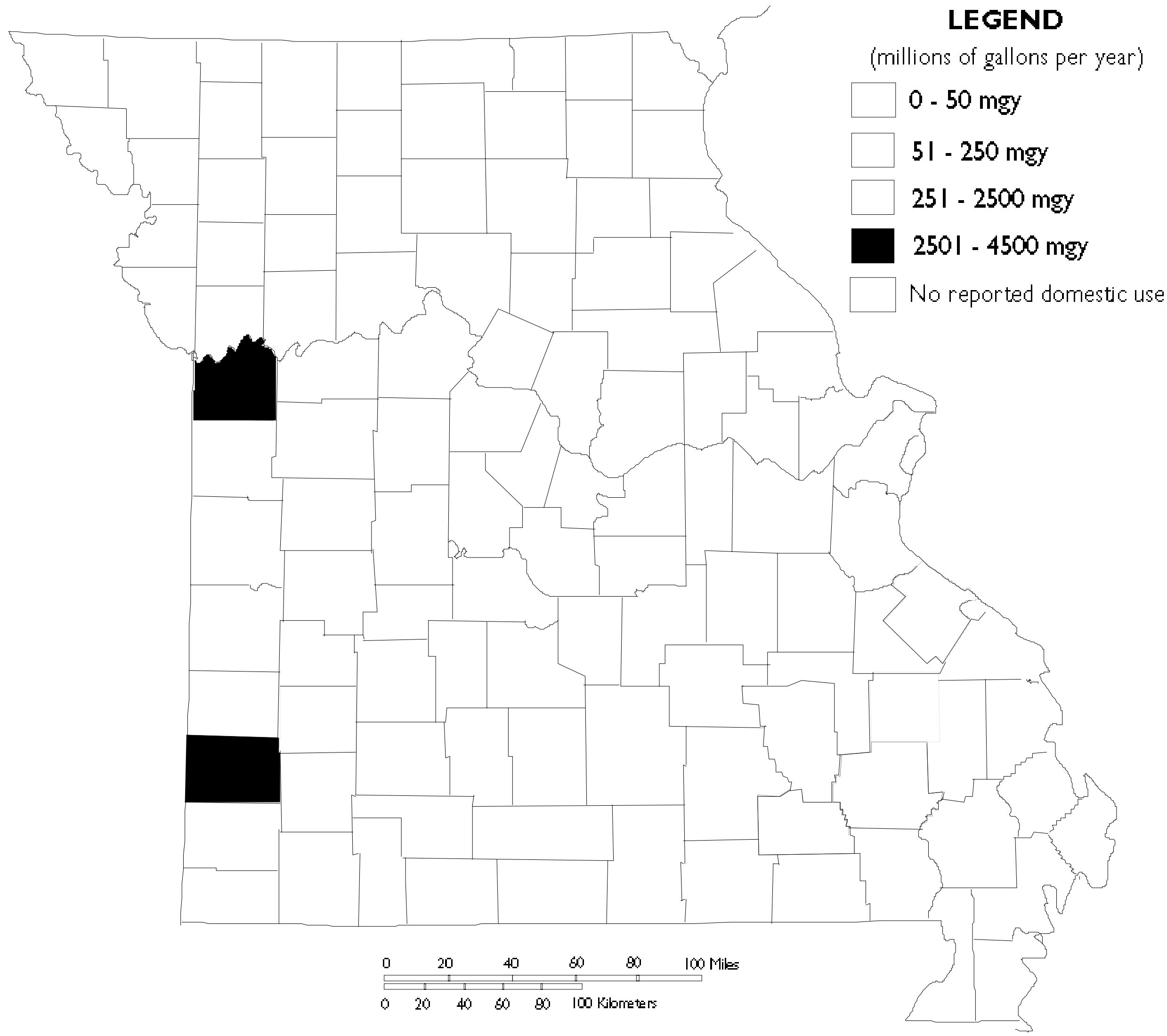


Figure 5. Sources of public water supply in Missouri: Percentages of population served.

stock watering, and the irrigation of gardens and orchards less than two and one-half acres in size.

In this report, the phrases “residential water use,” “domestic water use,” and “household water use” are used interchangeably, and the DNR definition applies equally to each. Residential water supplies come from: publicly-owned water suppliers, privately-owned water suppliers, and private water wells. Estimates of residential water use are available from: the Major Water Users Database maintained by the DNR’s Division of Geology and Land Survey, a census of public water supply systems conducted by the DNR’s Division of Environmental Quality, and the U.S. Geological Survey (USGS) National Water-Use Information Program. Additional data indirectly related to residential water use can be found in a database cataloguing all wells drilled since 1989. It is available from the DNR Division of Geology and Land Survey. Among these sources, there is little consensus regarding either the number of residential water users or the quantity of water they use.

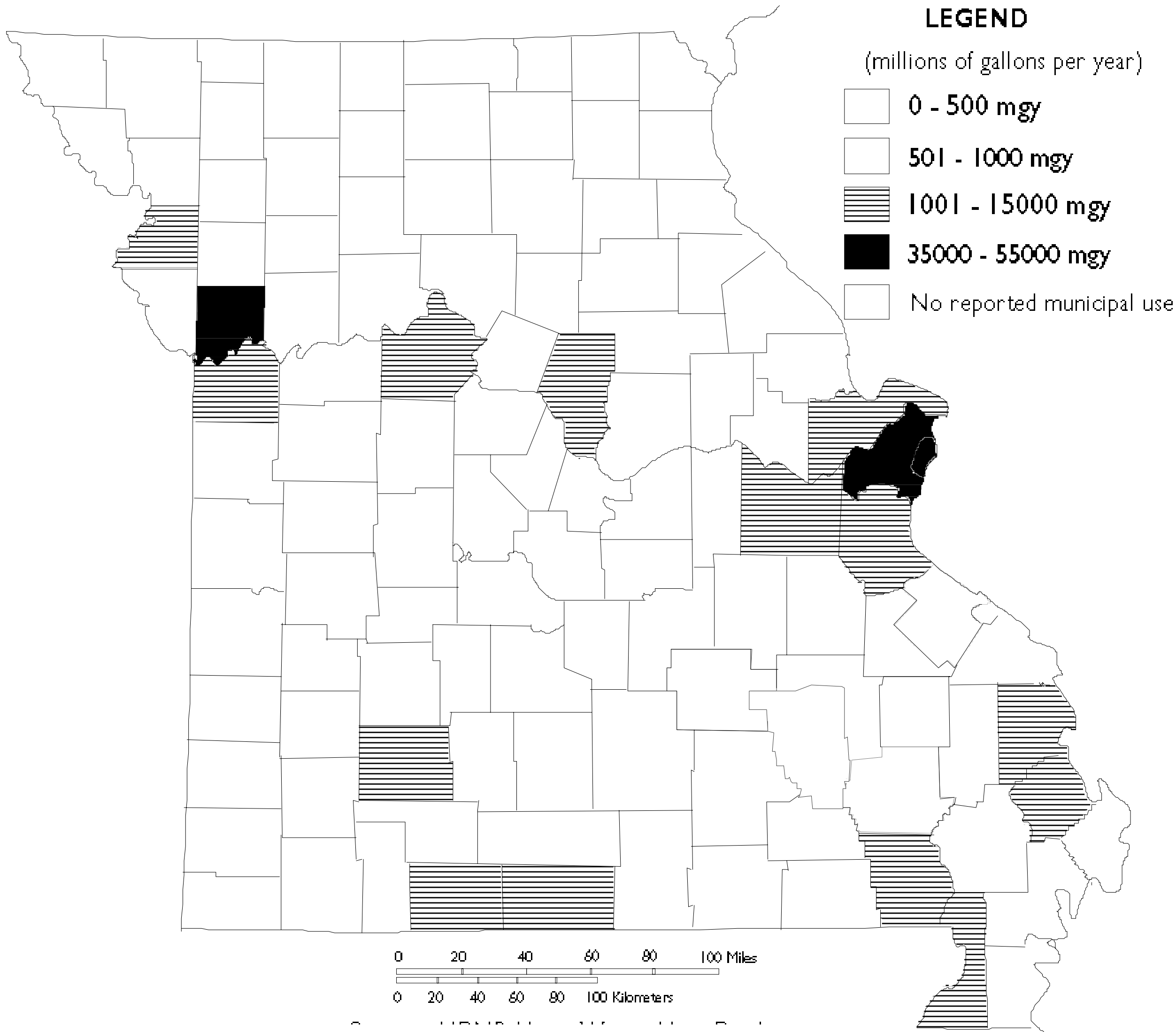
Because residential water uses permeate both our home and working environments, they constitute the bulk of general water sup-



Source: DNR Major Water Users Database

Figure 6. Domestic water use in Missouri, 1993

ply uses nationwide. In the Major Water Users Database maintained by the Department of Natural Resources, residential water supply is reflected by consumption in the domestic and municipal water use categories (figures 6 and 7). For the calendar year 1993, total reported domestic water consumption surpassed 15 billion gallons, and reported municipal consumption totalled slightly more than 233 billion gallons of water. Once again, however, it is important to note that some commercial and industrial water users obtain their water from municipal sources. In other words, the municipal water use category includes “hidden” industrial uses, and does not provide a truly accurate depiction of residential water supply.



Source: DNR Major Water Users Database

Figure 7. Municipal water use in Missouri, 1993

The Department of Natural Resources also collects and periodically publishes data on public water supply systems in a "Census of Missouri Public Water Systems." The public water supply census contains a great deal of information about Missouri's public water systems, including service area population, source of water supply, water treatment, and water quality data. Locations and surface acreage of public water supply lakes are also included. This format is currently under revision; future editions will be more oriented towards system information (such as water source and population served) and will be titled "Inventory of Missouri Public Water Systems." Water quality data and related information will appear sepa-

rately in a publication still under development. The 1991 census indicates that 418 billion gallons of water were delivered in 1991 from the state's public water systems. As with many sources of water use data, public water supply information is compiled from reports by individual facilities, and overall figures should be regarded as rough estimations.

Estimates of the number of domestic water users fall across a relatively wide range. The 1991 "Census of Missouri Public Water Systems" estimates that there are approximately 1,400 community water systems operating in Missouri. They provide water to nearly 4.8 million Missourians overall, which is more than 93 percent of the state's population.

Unlike other sources of information providing insight on Missouri's public water supply systems, the census of public water suppliers divides public water systems into three subcategories—municipal water suppliers, public water supply districts, and miscellaneous water suppliers. Since 1939, public water supply districts have grown in both number and in populations served. Currently, there are approximately 240 water supply districts serving Missouri (figure 8). In total, these districts provide close to 43 billion gallons of water

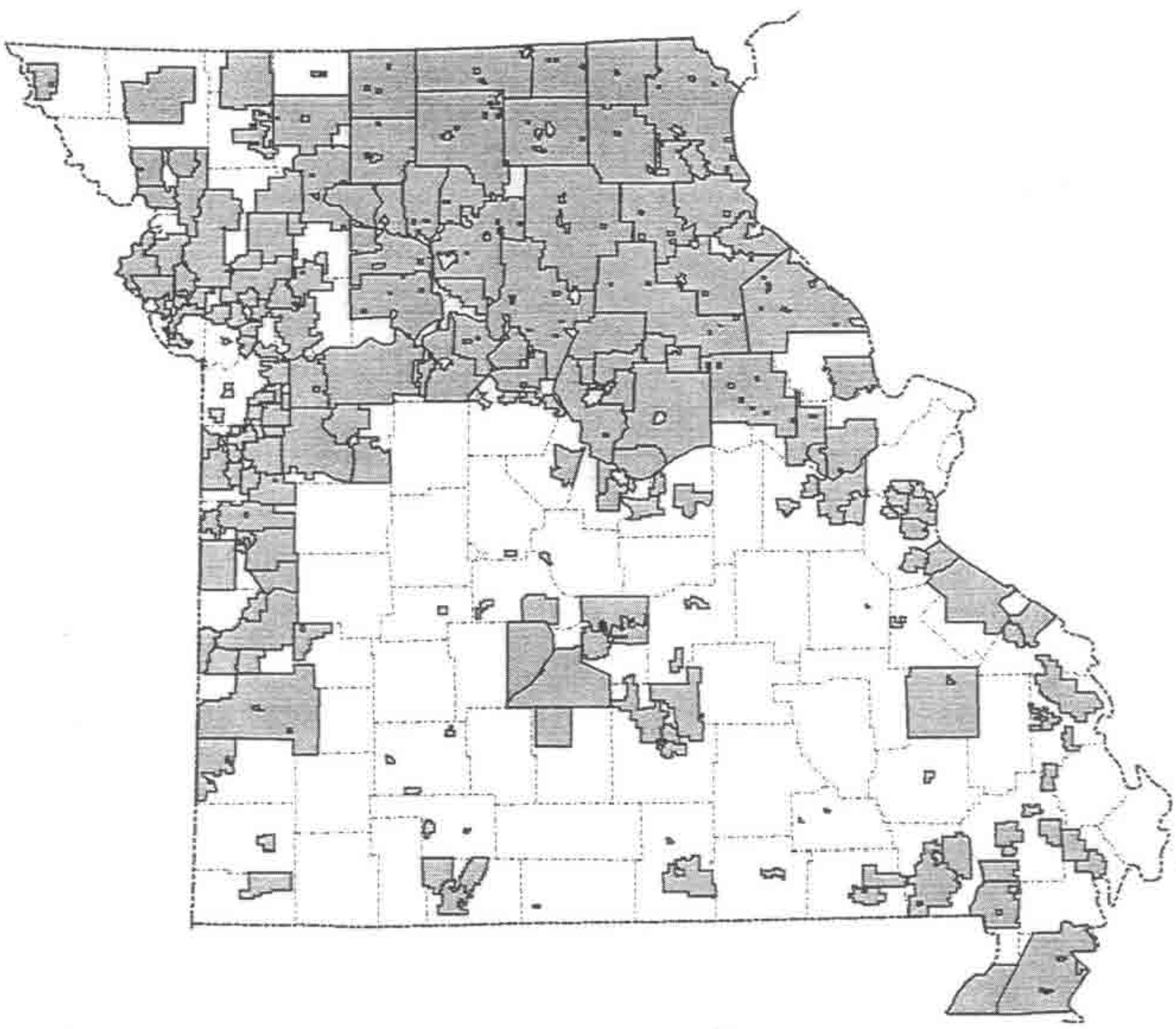


Figure 8. Public water supply districts in Missouri, 1996

yearly to 600,000 people, an average of 194 gallons per person per day.

The bulk of publicly-supplied water distributed in Missouri, however, is provided by municipalities. Slightly more than four million citizens of Missouri receive their water from city supplies. Municipal water suppliers, as a whole, distribute much more water than public water supply districts. Current estimates indicate that municipalities provide approximately 369 billion gallons of water yearly to the public. Daily consumption from municipal supplies is greater than from public drinking water districts, averaging nearly 249 gallons per person per day.

A third division of water supplies exists, accounting for the remainder of publicly supplied water sources. These suppliers include facilities such as mobile home parks, self-providing institutional users, and some subdivisions that represent the smallest block of public water supplies in terms of both distribution and facility capacity. Current estimates show that these sources distribute nearly 5.8 billion gallons yearly to the public, an average of 136 gallons per person per day.

The USGS also collects information regarding Missouri's public water suppliers. The USGS estimates that, in 1990, 4.1 of Missouri's 5.1 million citizens were connected to public water supplies. According to the USGS, per capita water use is approximately 166 gallons of water per day, but this figure does not distinguish among municipal providers, public water supply districts and other public water systems. USGS Circular 1081, *Estimated Use of Water in the United States in 1990*, estimates that public water suppliers in Missouri delivered 247 billion gallons of water to domestic, commercial, industrial and other public water users in the 1990 calendar year. Of that quantity, 51 percent was reported allocated to domestic users, the remainder being split evenly between industrial, commercial, and "public" (see PUBLIC WATER USE, page 21) uses. The USGS has further estimated that an additional 22.6 billion gallons of water were consumed by domestic water users not connected to public water supplies.

INDUSTRIAL AND COMMERCIAL WATER USE

The Major Water Users Program of DNR defines industrial water use as water used in "producing marketable (or economic) products." As previously noted, there is a significant overlap between the industrial category and the municipal category, which often represents the source of water supplies used to provide these products. Reported industrial water use in 1993 was nearly 23.5 billion gallons, an increase of 4.7 billion gallons over the five year period beginning in 1987. Water use categories developed by the United States Geological Survey are more specific; commercial water use and industrial water use exist as separate categories. While both categories reflect economic production, the industrial water use category is defined as water use in facilities which manufacture products. The commercial water use category, on the other hand, reflects water use by motels, hotels, restaurants, office buildings, and other commercial facilities.

COMMERCIAL WATER USE

Estimated Use of Water in the United States in 1990, published by the USGS, reports that commercial water use in Missouri totalled approximately 29.6 billion gallons of water in 1990. Of the total water consumed, 21.5 billion gallons were delivered from public supplies, with the remainder coming from self-supplied withdrawals (figure 9). While public water supply deliveries have historically been taken from both ground and surface water sources, the USGS report indicates that 1990 self-supplied withdrawals came exclusively from groundwater sources.

INDUSTRIAL WATER USE

Water use figures similar to those for commercial water use are provided for 1990 industrial water use in Missouri. Total withdrawals for industrial water use in 1990 are estimated by the USGS to have exceeded 79 billion gallons. 61 percent of the water used by industry was delivered by public water systems (figure 10), compared to 73 percent for commercial users. Self-supplied withdrawals ac-

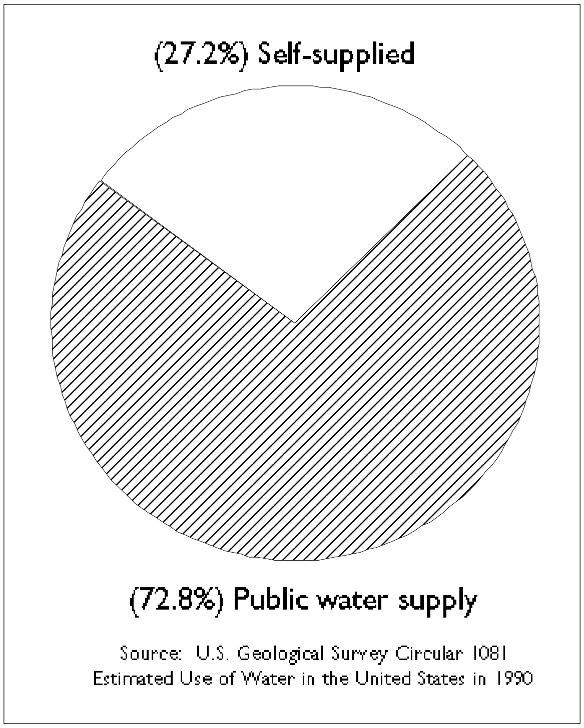


Figure 9. 1990 commercial water use deliveries in Missouri: public or self-supplied

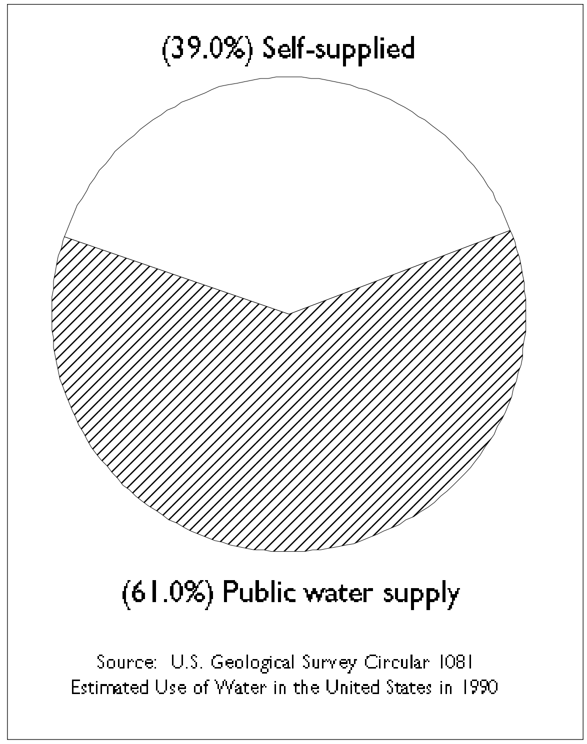


Figure 10. 1990 industrial water use deliveries in Missouri: public or self-supplied

counted for the remaining 31 billion gallons of water used, the bulk of which was extracted from groundwater sources (figure 11).

Describing water use characteristics for individual industrial water users is somewhat beyond the scope of this State Water Plan Volume. Nevertheless, it is possible to broadly characterize water use for several major industrial groups. Using the methodology outlined in the section titled “Calculating Personal, Household and Municipal Water Use,” we can construct a statewide distribution of water use for specific industrial groups. For example, water use in the printing and publishing industry is widely dispersed across Missouri, but centered around the St. Louis and Kansas City metropolitan areas (figure 12). Table 1 lists the ten industries in Missouri using the most water per employee per day in 1992.

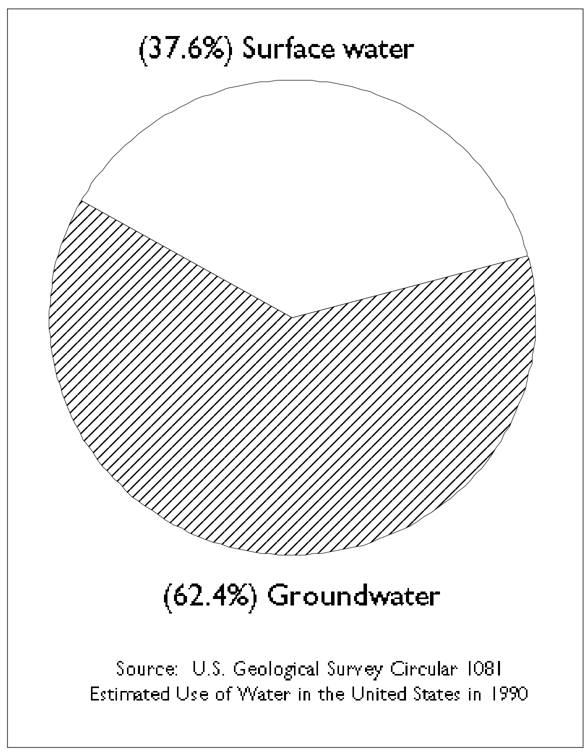
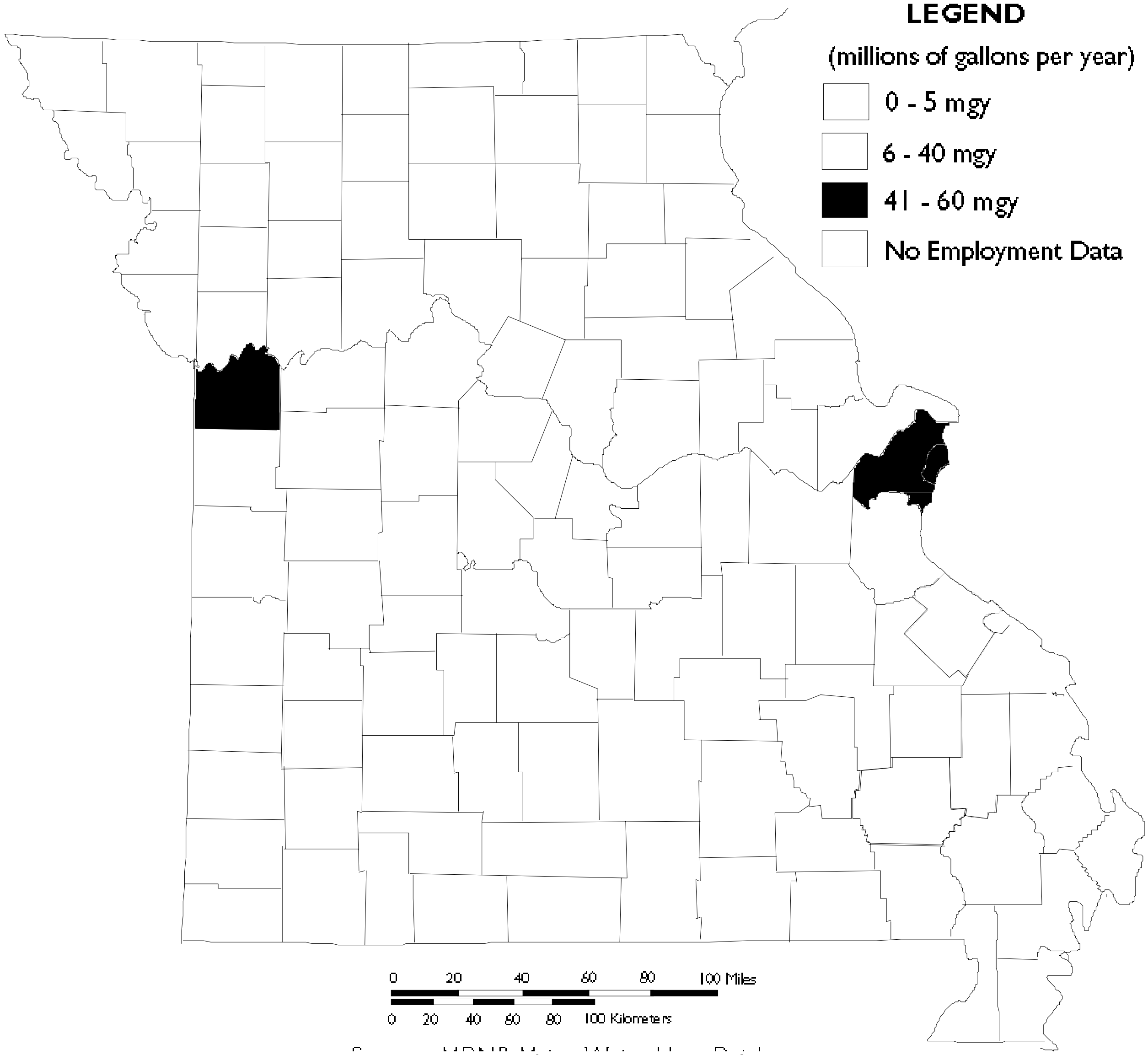


Figure 11. Sources of water for self-supplied industrial water use in Missouri, 1990



Source: DNR Major Water Users Database

Figure 12. Water use in printing and publishing, 1992

We can make several comparisons among the major groups of water-using industries by looking at their water use characteristics individually. The most obvious comparisons reflect the amounts of water each group requires to operate. A 1986 U.S. Census report produced by the U.S. Census Bureau titled *Water Use in Manufacturing* indicates that producers of chemicals and allied products had the highest total intake of water among all major industrial groups, followed closely by primary metal and paper industries. The opposite end of the industrial water use spectrum is occupied largely by “high-tech” industries and other specialized manufacturers.

The 1986 report demonstrates that the degree of reliance upon water delivered by sources of public supply decrease as water quantity requirements for major industrial groups increase. To illustrate, the total water

TABLE 1
Water Use Rates for Selected Industries
1982 U. S. Census of Manufactures: Water Use in Manufacturing

Industry	**Water Use Rate (1)**	**Approximate Water Use, Statewide (2)**
Petroleum Refining	2,639	57,310,311
Paperboard Mills	2,461	53,448,939
Malt Beverages	1,451	1,986,338,870
Industrial Inorganic Chemicals	1,177	379,212,297
Cyclic Crudes and Intermediates	1,135	3,936,653
Gum and Wood Products	1,135	310,581,183
Organic Chemicals	1,135	724,965,683
Industrial Organic Chemicals	1,135	919,104,821
Miscellaneous Petroleum and Coal	850	108,600,275
Agricultural Chemicals	840	974,565,367

(1) Gallons of water used per employee per day
(2) Approximate volume of water used in a year by industry, calculated by multiplying rate of use by total employment statewide, and again by 365 days.

intake of the "Chemical and Allied Products" major industrial group was approximately 3.4 trillion gallons of water; publicly supplied water accounted for only six percent of that total. On the other hand, water supplies taken from public sources accounted for nearly three-quarters of the 74 billion gallons of water used by the "Electric and Electronic Equipment" industrial group in the same period.

This research also sheds some light upon the purpose by which water is used in the manufacturing process. Most notably, it distinguishes between water which comes into contact with products and materials (and includes water consumed in the manufacturing process), and that which does not. Where water comes directly into contact with products or materials, it is considered to be used in production or processing. Water used in cooling and condensing, on the other hand, is defined as including "water used...in conjunction with the operation of process equipment, but which

does not come into direct contact with products or materials." Of the 18 major industrial groups surveyed for this report, 11 used more water in production and processing (involving direct contact with products or materials) than in cooling and condensing.

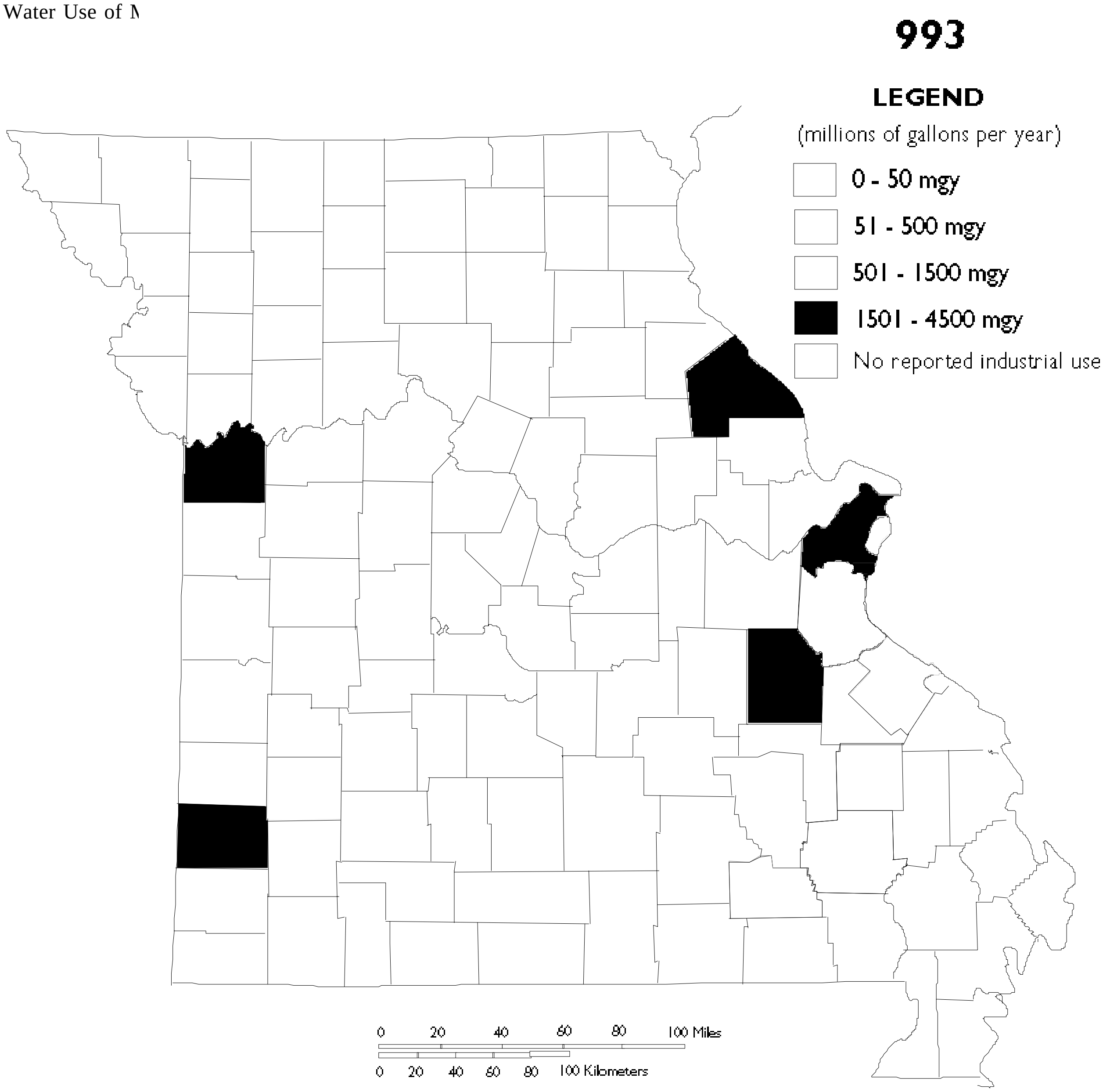
In a statewide context, industrial and commercial water use is a function not only of the specific needs of the industry, but also of the distribution and size of the industry statewide. It is a basic fact that some industries use more water than others. However, even industries demanding exceptionally large volumes of water may not be significant on a statewide or regional basis if they are small in size or number. For example, the petroleum refining industry uses slightly more than 2,600 gallons per employee per day in its operations, which is the highest "per employee" rate found in Missouri. Because of this, it is tempting to conclude that petroleum refineries in Missouri must be one of the biggest industrial water users in the state. However, in 1990 there were only four petroleum refineries currently operating in Missouri and none of them had more than 49 employees. Considering this, we can conclude that the amount of water required in petroleum refining operations statewide is, in fact, comparatively low. Unfortunately, a characterization of this sort might lead one to infer that petroleum refining is not a significant use of water. On a local or regional scale, any use of water can be important both to the user and others who may be affected by the use.

Because most suppliers of public water rely upon groundwater reserves to some extent, public water supply in Missouri is in many ways a function of regional hydrogeology. However, when looked at in terms of deliveries (as it is here), it is largely a function of population distribution. Water consumption (residential, commercial and industrial combined) correlates closely with economic and population trends. As a result, we might expect to find water supply consumption highest in urban regions. A quick glance at the statewide distributions of domestic, municipal and industrial water consumption bears this expectation out. Water use in the cities of Hannibal, Macon, Jefferson City, Joplin and Springfield appears on the statewide map of domestic water use (figure 6), as does water use on the Fort Leonard Wood military base. Similarly, the map of statewide municipal water use (figure 7) reflects water use for the cities of Springfield, Columbia and Cape Girardeau.

The largest metropolitan areas in the state, Kansas City and St. Louis, show heavy usage in both the domestic and municipal water use categories. Both of these heavily urbanized regions are by far the largest water supply markets. The metropolitan areas of Kansas City and St. Louis have a population of more than four million people. Adding the domestic, municipal and industrial use categories (keeping in mind the existing "overlap" among these categories- see DEFINITIONS OF PUBLIC WATER SUPPLY, above) allows us to very roughly estimate cumulative residential and commercial/industrial water use. These totals can be used to make a very preliminary comparison of water supplies consumed in the Kansas City and St. Louis metro areas and the state as a whole. Employing this method (which, at best, provides only a rough estimate), we can see that, together, Kansas City and St. Louis account for approximately two-thirds of Missouri's residential, commercial and industrial water consumption.

Statewide, domestic, municipal and industrial users reported consumption of slightly more than 237 billion gallons of water in 1993, which was 102.2 percent of the reported use in these categories for 1987. This increase correlates closely with the expected increase in population over a five year period.

A glance at the distribution of major industrial water users across the state reveals a tendency towards heavy use between St. Louis and Iron counties (figure 13). Although a variety of uses contribute to the elevated levels of consumption in this region, mining and related industries account for the bulk of reported industrial water uses. However, a number of other factors may also contribute to this trend such as reporting recruitment and accuracy, and geographic suitability. Currently available water use information provides little



Source: DNR Major Water Users Database

Figure 13. Industrial water use in Missouri, 1993

insight into the distribution of reported industrial water use. Improvements in water use data collection are needed to fully explain regional industrial water use patterns.

Industrial and commercial water use is closely tied to local and regional growth patterns. Water use by specific industries and commercial enterprises have their real impact on this scale. Individual users affect local water quantity and quality, in terms of both the water they withdraw from local supplies and the water they return to the hydrologic environment. The interest each individual user has in local water resources varies according to the requirements of the industry. In regions of continuing economic growth, the needs of diverse industrial and commercial water users periodically clash with each other. They may

also conflict with the water supply needs of residential users. Strong growth in local or regional industrial patterns may strain public water supplies. Alternately, a decline in the number (or size) of industrial users may create surplus local or regional water supplies.

PUBLIC WATER USE

Public water uses, broadly interpreted, provide benefits to the private citizen through community-wide applications. Common public uses include allocations of water for firefighting, park maintenance, public swimming pools, and street cleaning. These uses, while not as dependant upon high quality water as residential and commercial uses, are nonetheless important elements of the services a municipality provides to its citizens. Similarly, the relatively low per capita volume of water supplied for public uses should not detract from the importance of these uses. The current reporting method employed by the Department of Natural Resources does not allow public water uses to be differentiated with the existing categories; public water uses are encompassed within the municipal water use category. Public water use is partially reported in the recreation water use category of the Major Water Users Database. The recreation water use total of the Major Water Users Database can be looked upon as a subset of overall public water supply usage. The 1990 USGS water use report does include information on public water use and losses, however. For the state of Missouri, public water use (with losses included) was estimated to be slightly more than 50 billion gallons in 1990.

USAGE CHARACTERISTICS OF WATER SUPPLY

Residential, commercial and industrial water uses together encompass a wide variety of applications. Domestic water users must have a water supply that can meet basic human water requirements. Factories, hospitals, restaurants and office buildings all need dependable water supplies to conduct business on a daily basis.

The various uses of the public water supply make broad characterizations difficult. Water is essential to every family and virtually all commercial and industrial operations. Despite the indispensable nature of our water suppliers, different users look to their local water supplies to meet different needs. Water quality, for example, is important to most users, vital to many others, and not important at all to some. Having a clean, safe water supply is essential to domestic life. High quality water is important in food and beverage production, and essential to health care. Many commercial enterprises, such as restaurants, could not conduct business without quality water supplies. Some industrial and commercial users may need water that meets unusually strict quality standards; for example, water of exceptional quality is required for many industrial applications, such as petroleum refining and chemical production. On the other hand, some industrial users may find that untreated water is sufficient to meet their needs.

Other users may find water quantity a more important characteristic of their needs. For example, production of malt beverages has been estimated to require nearly 1,500 gallons per employee per day; manufacturing of electronic components and accessories often requires less than 10 percent of that amount.

For yet another user, the timing of the water received may be more important than its quality or quantity. Some businesses may require a constant amount of water to be available throughout the day; many others use considerable amounts of water at certain times of the day, and almost none at others. Residential water use, on the other hand, varies mainly with the seasons. Most notably, urban domestic water users use substantially more water during the summer months than during other seasons, largely due to the practice of watering lawns and gardens.

Infrastructure is another important characteristic of water supply, and represents the basic equipment, services, and installations required for a public water supply system to function properly. If the infrastructure of a water supply system is inadequate, it may not

be able to meet the basic water requirements of the service population. In drought, the quality of a water distribution network directly affects the health and welfare of the population it serves. If the network is in good condition, the impact of drought can be successfully blunted. This diminishes threats to public health and reduces property damage. On the other hand, a poor quality distribution network may not be able to meet even the most basic human needs, and may actually worsen the situation.

CONSUMPTIVE USE VERSUS RETURN FLOW

Water supply return flow and consumptive use estimates for Missouri are available from the USGS. Estimated consumptive use of residential water supplies in Missouri for 1990 was approximately 27.8 percent, slightly above the national rate of 23 percent. This percentage includes self-supplied water users as well as those taking water from public supplies. Because of leaky pipes and other shortcomings in distribution networks, most public water supply systems lose water in transit between the supply and end users. Commonly, transmission losses fall in the range of 10 to 15 percent (John Hoagland, personal communication, 1996). While leaky distribution networks are common sources of water loss, other problems such as inaccurate meters and unmetered connections also contribute to losses.

Consumption of water supplied for commercial and industrial uses in Missouri fell slightly below nationwide norms in 1990. Reported consumptive use of water supplied for commercial purposes in Missouri was approximately 6.7 percent, substantially less than the national estimate of 11 percent. Similarly, 13.3 percent of water supplied for industrial purposes in Missouri was reported "consumed" by end users, with the remainder returned to source waters for re-use.

In 1990, an estimated 109 billion gallons of water were withdrawn (from all sources) for economic purposes. Of that amount, an estimated 12.6 billion gallons was taken from Missouri's waters and not immediately reintroduced. The remaining 96.4 billion gallons were released back to surface or groundwater sources, becoming available once again for further use.

REALIZING THE COST OF PUBLIC WATER SUPPLY

Providing a reliable supply of water does not come without cost; each public water supplier faces operating expenses similar to those incurred by private enterprises, which must be passed on to consumers. According to a 1994 water rate survey performed by the Missouri Rural Water Association, the average cost for 5,000 gallons of water in a water district was $26.57, while the average cost for 5,000 gallons in a city was much lower, at $16.20. A similar survey performed in 1993 by the Missouri Municipal League provides insight on the ranges of municipal water rates found across the state (table 2).

TABLE 2

Municipal Water Rates for Selected Missouri Communities
"Water Rates and Policies in Missouri Municipalities"
Missouri Municipal League, November 1993

Municipality	Charge for 5,000 gallons	Municipality	Charge for 5,000 gallons
Sparta	$5.00	Foristell	$14.30
Hartville	$5.60	Liberty	$16.09
Charleston	$6.00	New Franklin	$17.00
Cole Camp	$6.00	Union Star	$17.25
Linn Creek	$8.25	Lamar	$17.45
Poplar Bluff	$8.81	Braymer	$17.80
Mountain Grove	$8.88	Savannah	$17.82
Weaubleau	$9.00	Plattsburg	$19.90
Windsor	$9.10	Goodman	$20.00
Branson	$10.85	Merriam Woods	$21.00
Knob Noster	$11.57	Ellsinore	$23.75
Osceola	$11.60	Fayette	$24.01
Hannibal	$11.70	Atlanta	$32.50
Sarcoxie	$11.90	Laredo	$33.00
Pevely	$13.00	Hunnewell	$40.45

Average residential water costs (for 5,000 gallons of water) were quite high in some regions, especially in the northeastern corner of the state. In the broadest terms, water rates were substantially higher north of the Missouri River, reflecting the poor quality and limited availability of groundwater supplies in that region.

LIVESTOCK WATER USE

INTRODUCTION

Although the foremost use of water associated with agriculture is crop irrigation, farm animals are also important consumers of water. Livestock water use is especially important in the Ozarks, where livestock and poultry products account for more than 75 percent of total agricultural sales. In 1992, the U.S. Census Bureau determined that the total market value of livestock and poultry products generated by Missouri farmers exceeded 2.4 billion dollars, accounting for 56.7 percent of all agricultural sales statewide.

DEFINITION OF LIVESTOCK

The Missouri Department of Natural Resources does not collect livestock water use data, but aquaculture data is collected in the "fish and wildlife" category. However livestock water use estimates are prepared by the USGS.

The term "livestock" is commonly used in association with cattle, hogs, sheep and horses. The USGS livestock water use category is typically expanded to include an "animal specialties" subcategory, which includes farmed fish (aquaculture), mules, burros, poultry, rabbits and mink. "Livestock water use" is defined by the USGS as water used in the production of livestock. Although the primary use of livestock water is to meet drinking water needs, livestock water use also encompasses evaporation from stock ponds, equipment and facility cleaning, waste disposal, product processing and transmission losses.

SOURCES OF WATER FOR LIVESTOCK

The majority of livestock water needs in Missouri are met by surface water sources. Livestock water use estimates prepared by the USGS in 1990 indicate that 74.5 percent of the estimated 20 billion gallons of water consumed by farm animals in 1990 was taken from surface water sources (figure 14). The surface water resources of Missouri are vast and include

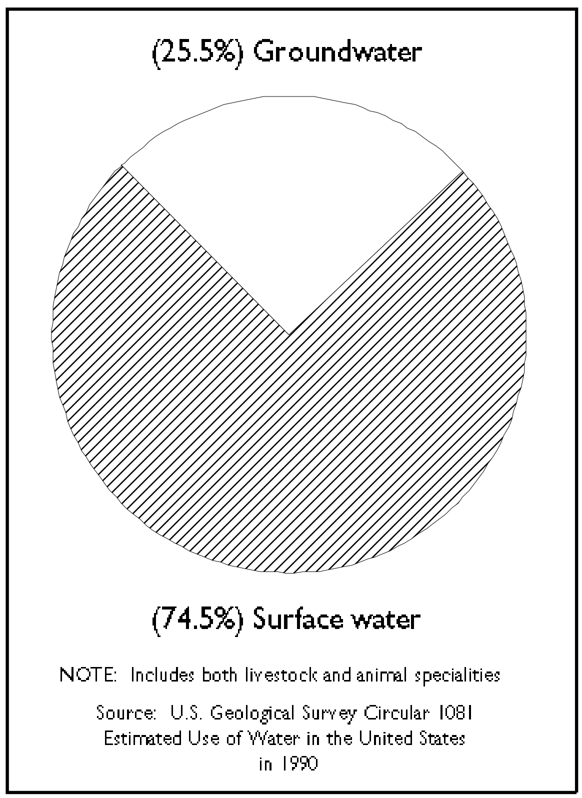


Figure 14. Sources of water used for livestock watering in Missouri, 1993

everything from the Missouri and Mississippi rivers to the ubiquitous farm ponds that dot the countryside. Most of the ponds rely upon runoff from storm events to replenish their supplies.

LIVESTOCK WATER USE

Because the Major Water Users Database does not collect information regarding livestock water use, no data is available from this source. The department does collect off-stream fish and wildlife water use data, which in part reflects aquacultural use. In 1993, total reported fish and wildlife major water use was approximately 33.4 billion gallons.

The amount of water consumed by livestock operations can be approximated through the use of coefficients. Estimates of livestock water use can be obtained by multiplying the per capita water requirements of farm animals by their populations. Using this methodology, the U.S. Geological Survey estimated 1990 livestock water use in Missouri at 20 billion gallons of water. Table 3 demonstrates this procedure using selected livestock populations derived from the *1992 Census of Agriculture* (U.S. Bureau of the Census). The livestock populations used in this estimate are not as inclusive as the populations used by the USGS (see DEFINITION OF LIVESTOCK, above), hence the slightly lower total estimate of 17 billion gallons. Using the 1992 livestock populations for the animals shown in table 3 and "per head" water use estimates developed by the U.S. Geological Survey, this procedure was used to approximate livestock water use by county for each county in Missouri (figure 15).

TABLE 3

Estimated Livestock Water Use
1992 U. S. Census of Agriculture and USGS National Handbook of Recommended Methods for Water Data Acquisition

	Inventory	**Water Use Coefficient (1)**	**Livetock Water Use (2)**
Beef Cattle	1,876,845	8.8	6,028,426,140
Milk Cows	215,920	27.4	2,159,415,920
All Calves	2,072,592	8.0	6,051,968,640
Sheep and Lambs	111,362	0.7	28,452,991
Hogs and Pigs	2,908,509	2.6	2,760,175,041
Total			17,028,438,732

(1) Gallons of water required per day for one animal
(2) Water use totals in gallons per year. Represents total inventory multiplied by water use coefficient, and again by 365 days.

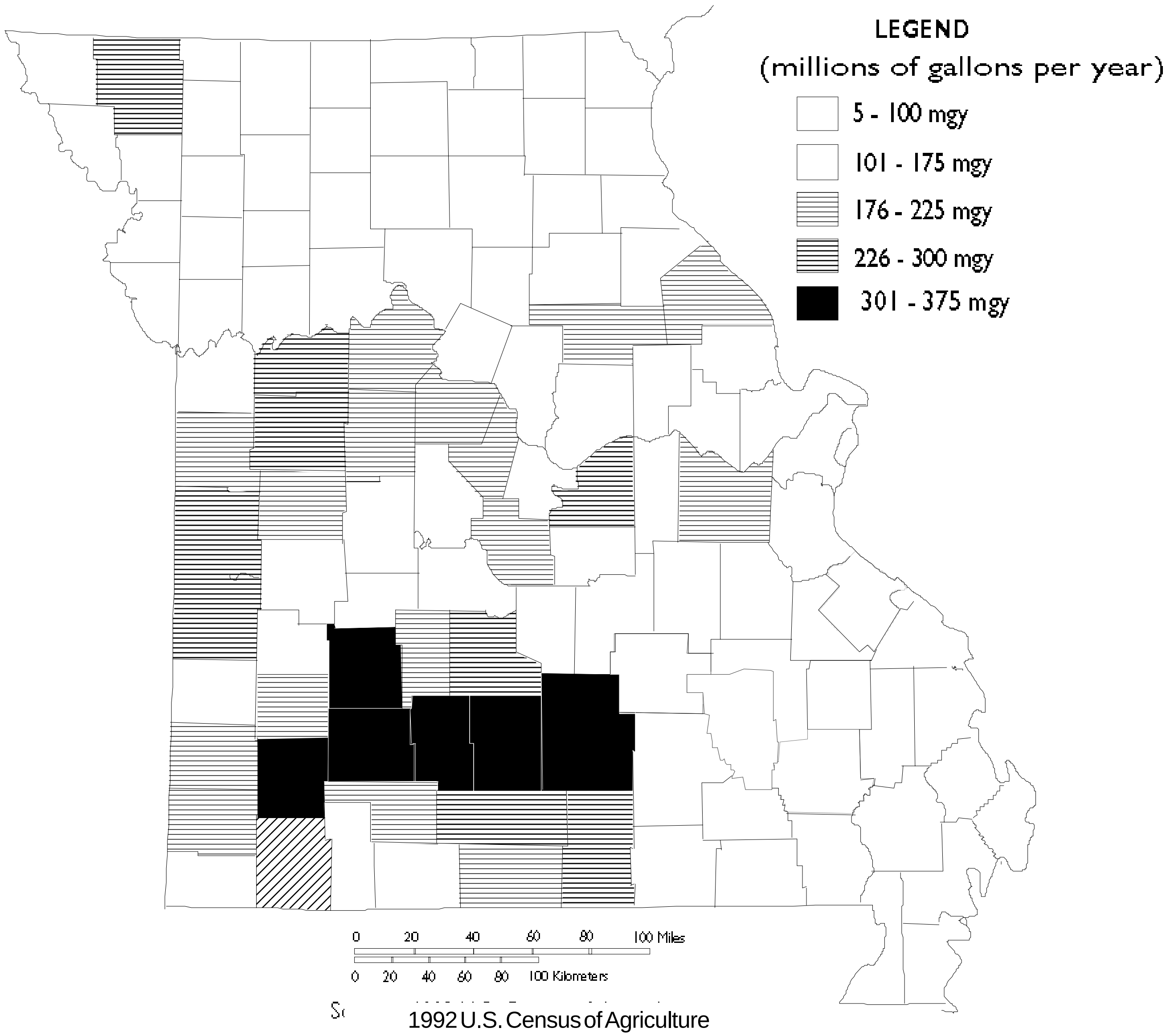
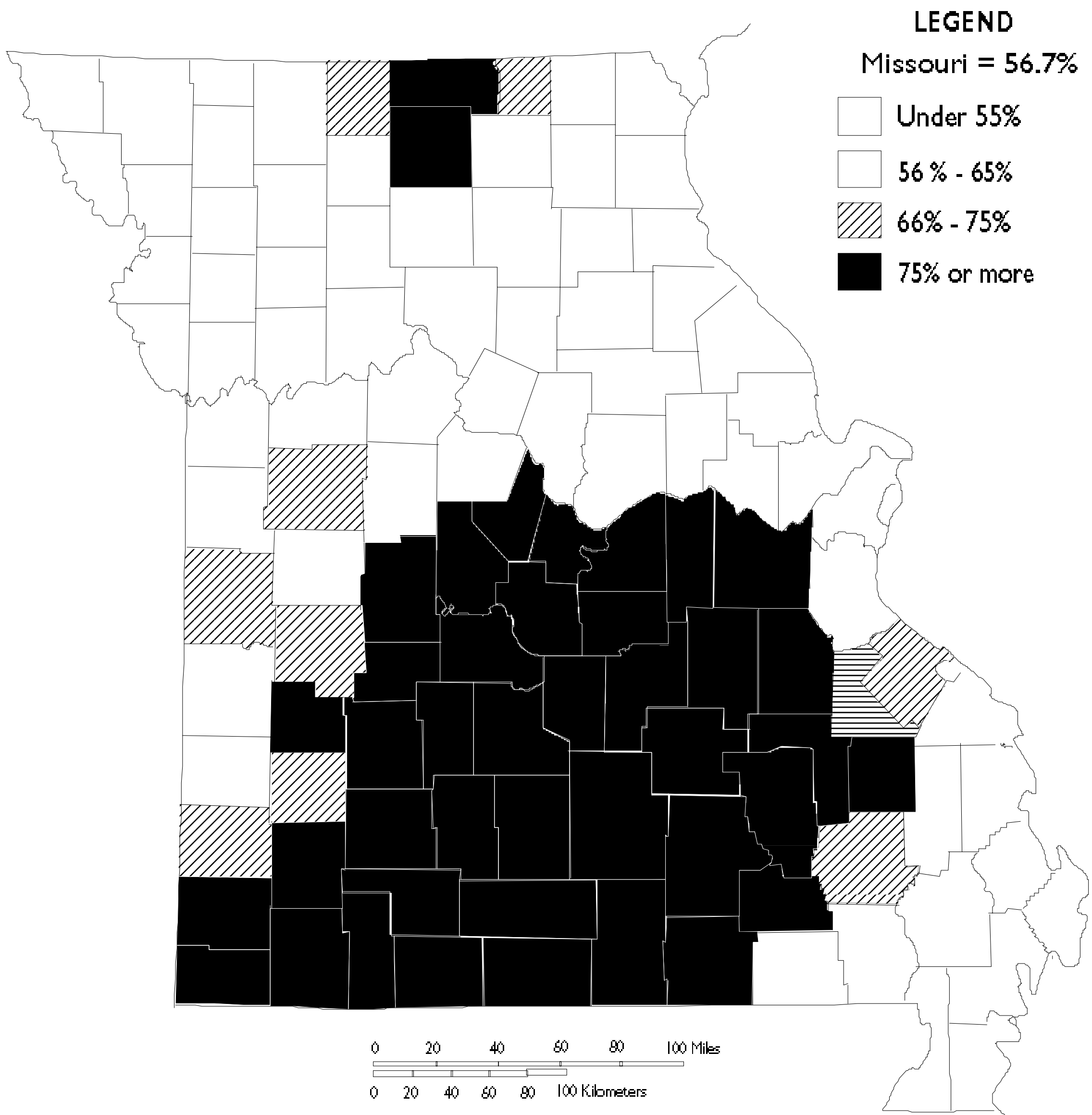


Figure 15. Livestock water use in Missouri, 1992

The Ozark Plateau is at the center of livestock water use in Missouri. Nearly every county for which livestock accounts for 75 percent or more of total agricultural sales is found within the Ozark Plateau (figure 16). Of the 10 Missouri counties having the highest estimated livestock water use, the first seven (Wright, Polk, Lawrence, Texas, Webster, Greene, and Howell counties) are located in the heart of the Ozark Plateau. Livestock water use in these seven counties accounted for an estimated 2.53 billion gallons in 1992, nearly 15 percent of the total DNR calculation.

Since the 1992 agricultural census, large corporate livestock operations (commonly called “concentrated animal feeding operations” or CAFOs) have emerged in several northern Missouri counties. Although CAFOs are associated with several kinds of livestock, increasing hog populations have had the most notable impact on livestock water use. As of December 1, 1995, the Missouri Crop and



Source; USDC, Bureau of the Census, Census of Agriculture

Figure 16. Livestock as a percent of total agricultural sales, 1992

Livestock Reporting Service estimated Missouri's hog population at 3.6 million animals, an increase of approximately 700,000 since 1992. Using the per capita water use coefficient given in table 3, this increase translates into approximately 664 million additional gallons of water consumed (above the 1992 estimate) in the 1995 calendar year.

Three regions of heavy livestock water use can be identified in Missouri: the Springfield Plateau and southwestern Ozark Plateau, the Osage Plains, and several counties along the southern edge of the Missouri River.

The Springfield and southwestern Ozark Plateau region is characterized by large cattle and horse populations, both of which require a great deal of water on a per capita basis. As a result, livestock water use estimates for counties in this region are among the highest in the state.

Livestock populations in both the Osage Plains region and the counties adjacent to the

Missouri River are more balanced. Cattle and horse populations are smaller, but are complemented by larger hog and sheep populations. Populations of hog and sheep require less water per head to maintain. Nevertheless, large herd sizes ensure that water use estimates remain high in these counties.

The prominence of livestock in the agricultural economy of the Ozarks correlates with the quality of surface water resources in the Ozark Plateau, which tend to be abundant and of good quality. Large volumes of water move freely through the groundwater system, returning to the surface in seeps, springs, and small streams. As a result, many streams in the Ozarks are able to provide sufficient volumes of clear, cool water in all but the most severe drought conditions.

The lowest overall estimated volumes of livestock water use are found in the counties of the Bootheel region. Cattle, horse, hog and sheep populations in the Bootheel are among the lowest in Missouri, reflecting an agricultural economy based upon crop sales rather than livestock production. Similarly, but to a lesser extent, the economies of several counties north of the Missouri River are more reliant upon crop sales than livestock production. Livestock water use in this region is moderate to light; water supplies are of limited quality and availability, and may be a limiting factor in livestock production.

LIVESTOCK WATER USE CHARACTERISTICS

Livestock water use, like irrigation, is almost exclusively associated with agricultural applications. Compared to irrigation, however, livestock water use is much less seasonally oriented. Although less water is used for livestock watering than for irrigation in Missouri, an adequate supply of water must be available throughout every season of the year to support livestock agriculture. Because livestock production is very important to the agricultural economy of Missouri (especially in the Ozarks), ensuring year-round availability is important. Many parts of the Ozarks have limited access to traditionally reliable sources of surface water, such as the Missouri and Mississippi rivers. Ozark streams, however, have proven to be dependable sources of water year-round, and are able to support the water needs of the region's livestock.

Water quality is likewise important to livestock agriculture. Like other animals, farm animals are subject to the harmful effects of poor water quality. Good water quality, on the other hand, is important biologically and economically; livestock watering is recognized as a "beneficial use" of water by Missouri's water quality standards.

CONSUMPTIVE USE VERSUS RETURN FLOW

The USGS estimates that the use of water for livestock watering in Missouri is 100 percent consumptive. However, only 60 percent of livestock water is directly consumed by livestock; the remainder is used to clean facilities and equipment, process livestock products, cool animals and machinery, and other related activities (see DEFINITION OF LIVESTOCK, page 25). Ultimately, this estimate of consumptive use reflects the lack of return flow data. Because return flow information is unavailable, consumptive use is assumed to equal total withdrawals.

LIVESTOCK IN MISSOURI AGRICULTURE

Fundamentally, the importance of livestock water use is obvious: water is essential to the life and health of farm animals. Steady supplies of quality water make livestock agriculture possible in most parts of Missouri. Some economic aspects of livestock agriculture can be linked to livestock water use. In particular, the distribution of the market values of livestock and poultry products (figure 17) relate closely to the projected livestock water use presented in figure 15. The range of market values for these products varies greatly statewide. According to the 1992 U.S. Census of Agriculture, total market values in Missouri ranged from slightly more than 95 million dollars in Barry County to $709,000 in St. Louis County (table 4).

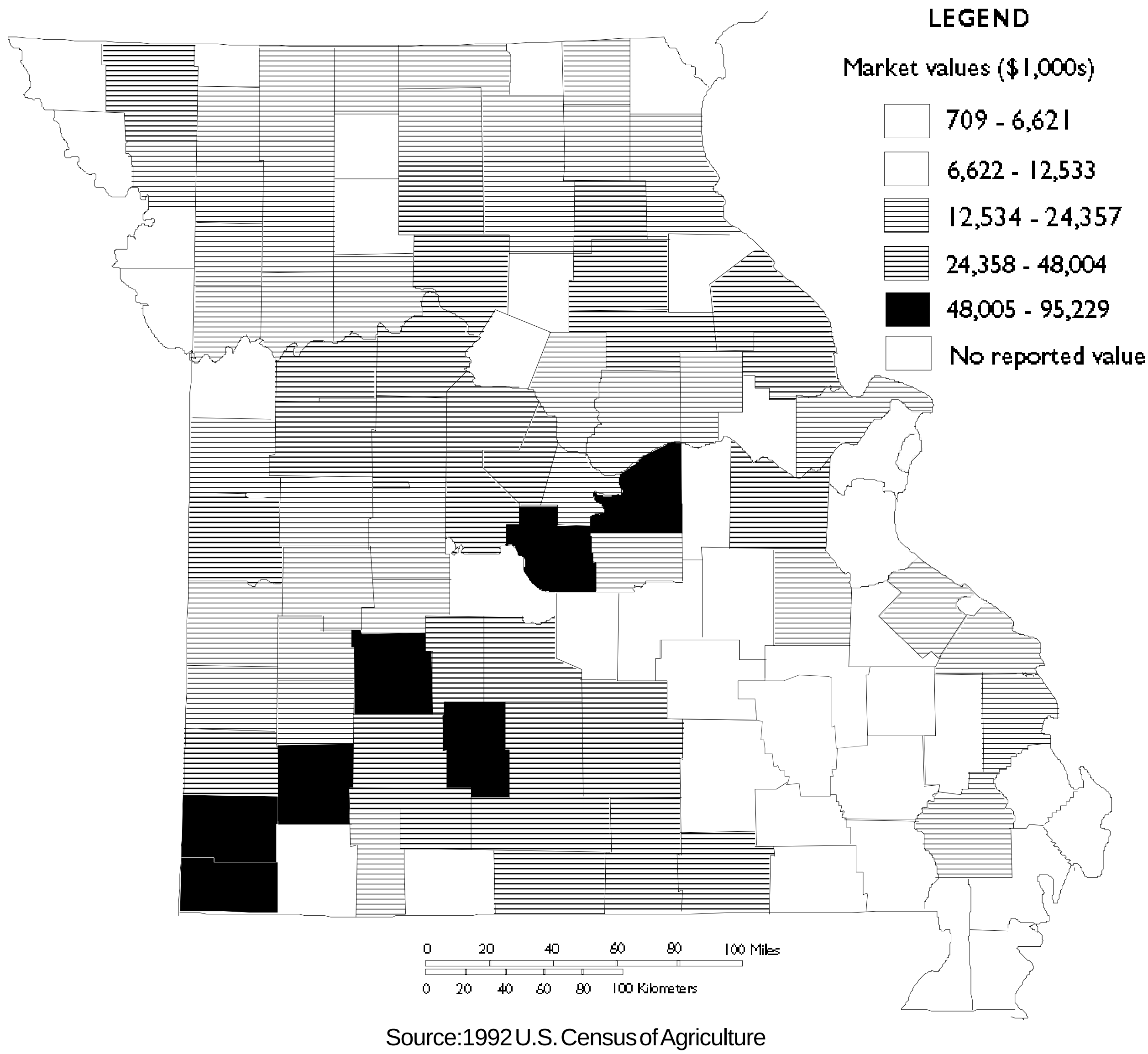


Figure 17. Market values of livestock and poultry products, 1992

TABLE 4
Market Values of Livestock and Poultry Products, 1992
Ten Highest (and Lowest) County Totals
1992 U.S. Census of Agriculture

Ten Highest	Market Values
Barry County	$95,299,000
Newton County	$84,209,000
McDonald County	$80,162,000
Lawrence County	$70,274,000
Miller County	$51,215,000
Webster County	$50,846,000
Polk County	$49,140,000
Osage County	$48,873,000
Wright County	$47,271,000
Bates County	$44,771,000

Ten Lowest	Market Value
St. Louis County	$709,000
New Madrid County	$893,000
Dunklin County	$1,264,000
Pemiscot County	$1,283,000
Mississippi County	$2,431,000
Carter County	$2,620,000
Wayne County	$3,294,000
Reynolds County	$3,302,000
Butler County	$3,302,000
Shannon County	$4,857,000

IRRIGATION WATER USE OF MISSOURI

INTRODUCTION

Irrigation is an important component of Missouri's agriculture. A comparison of irrigated and dry land corn yields for the years 1978 to 1994 shows that, in this period, mean corn yields from irrigated lands surpassed dry land corn production by an average of approximately 45 percent. Similarly, irrigation resulted in improved annual soybean yields per acre by an average of nearly 35 percent (Ron Plain, University of Missouri Agricultural Extension, 1994 Irrigation Survey). Irrigation makes this possible for two reasons: it increases the productivity of each individual plant, and it allows farmers to grow more plants on each acre of land.

In some ways, these figures still understate the true value of irrigation. In terms of economic benefit and food production, some arable lands would be worth substantially less if irrigation were not practiced. In some cases, irrigation practices can mean the difference between putting land into agricultural production and leaving it fallow.

DEFINITION OF IRRIGATION

Every year, the Missouri Department of Natural Resources collects irrigation water use data. In the Major Water Users Database, irrigation information can be found in both the "irrigation" and "domestic use" categories, depending upon the acreage of the irrigated land. For the purposes of major water use reporting in Missouri, "irrigation water use" is defined as "water required to supplement plant growth on land more than 2.5 acres in size." Irrigation information for lands having areas smaller than this (typically, gardens and orchards) is included in the "domestic use" category. Irrigation water use is commonly thought of as exclusively an agricultural activity, but it also applies to uses such as watering public and private golf courses.

SOURCES OF IRRIGATION WATER

In Missouri, water used for irrigation is withdrawn predominantly from groundwater sources. Of the 148 billion gallons reported used by irrigators in 1993, only six percent came from surface water diversions (figure 18). This percentage is much lower than the U.S. Geological Survey (USGS) estimate of 63 percent for the United States as a whole. However, in some parts of Missouri, irrigation withdrawals from small freshwater surface supplies (such as farm ponds and creeks) may be underreported and underutilized as well. Most of the water withdrawn for irrigation in 1993 was taken from alluvial wells in the Bootheel region of the state and the flood plain of the Missouri River. Elsewhere in Missouri, deep groundwater wells serve as the source of irrigation water, most notably in the Springfield Plateau region.

IRRIGATION WATER USE

Both the Major Water Users Database and USGS National Water-Use Information Program data indicate that, in 1990, Missouri irrigators used approximately 370 million gallons of water per day (or 416,000 acre-feet throughout the year). Major Water Users Database data indicates that, by 1993, irrigation water use in Missouri had risen to 405 million gallons per day.

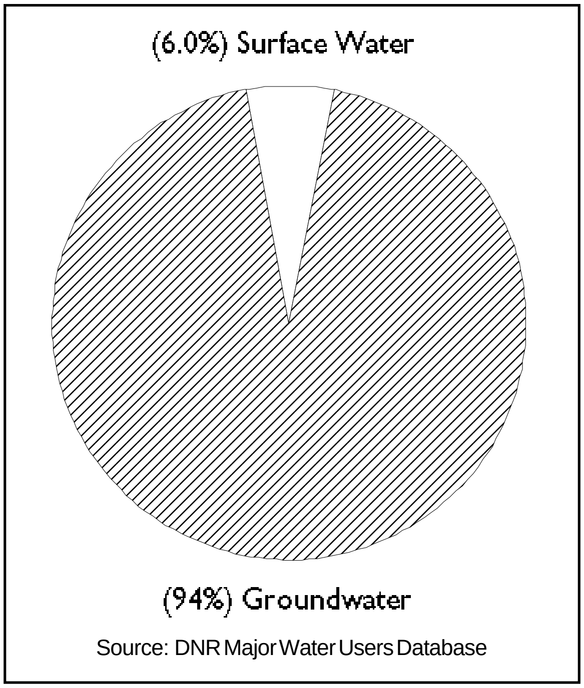


Figure 18. Sources of water used for irrigation in Missouri, 1993

At present, most of the water used for irrigation is applied in the southeastern Bootheel corner of the state (figure 19). The Bootheel Region (in this context, part or all of Bollinger, Cape Girardeau, Stoddard, Scott, Mississippi, New Madrid, Pemiscot, Dunklin, Butler and Ripley counties) applied more than 140 billion gallons of water to irrigated crops in 1993, fully 95 percent of the statewide total. Outside of the Bootheel, other traditional centers of irrigation agriculture in Missouri (such as Audrain County and its environs, as well as Barton, Jasper and Dade counties) show considerable use as well.

Total reported irrigation water use has been rising steadily since the late 1980s. In 1990, the DNR made a concerted effort to increase registration of irrigators in the counties of the Bootheel region. As a result, the quantity of water reported to the Major Water Users Program between 1987 and 1993 as irrigation use nearly doubled, going from 84 billion gallons in 1987 to 148 billion gallons in 1993. During this period, reported acreage under irrigation also increased, but at a lower rate. Slightly more than 302,000 acres were reported irrigated by major water users in 1993, an increase of approximately 59 percent from 1987.

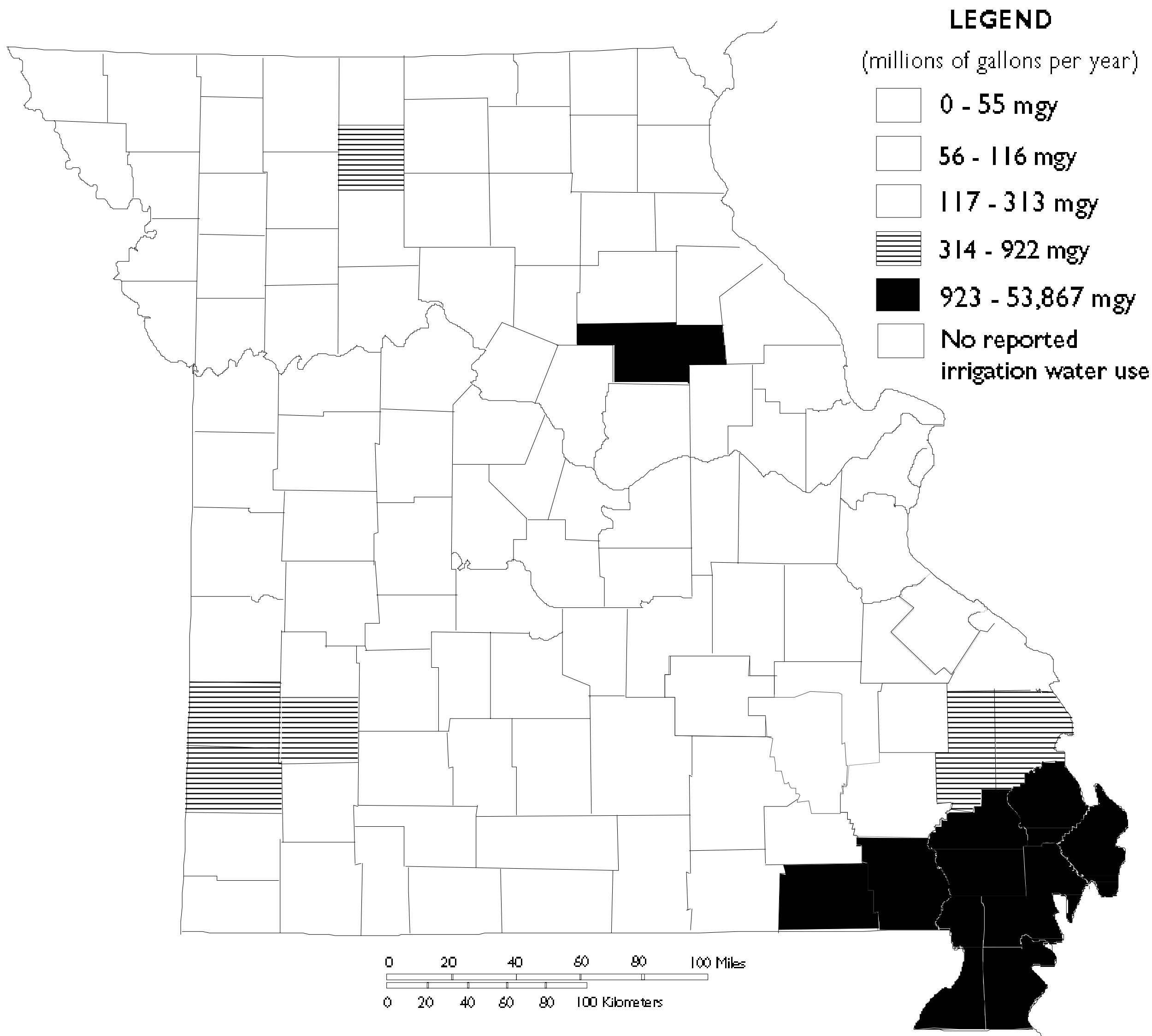
The 1992 United States Census of Agriculture also provides information on the acreage of irrigated land in Missouri. The Census reports 709,000 acres irrigated overall in 1992, about a 32 percent increase over 1987.

DISTRIBUTION OF IRRIGATION WATER

Irrigation agriculture in Missouri can be found throughout the state, but is predominant in the Bootheel region. Nearly one-half of the state's irrigators operate in the Bootheel; Butler, Stoddard and New Madrid counties alone account for approximately one-third of the state's total irrigating farms (figure 20). The extensive use of irrigation in these southeast Missouri counties can be attributed to a number of factors, all of which relate closely to the regional attributes of the Bootheel. The alluvial topsoils of the Mississippi River flood plain, while fertile, have a relatively poor water-holding capacity. At the same time, the water table is very close to the surface, making extraction easy and inexpensive. In addition, the Bootheel topography, while very level, slopes gently towards the Mississippi River and provides good drainage and low erosion rates. Unlike irrigators in other parts of Missouri, Bootheel growers also irrigate rice and cotton fields, which are water-intensive crops (Don Pfost, personal communication, 1995). Taken together, all of these factors create a unique situation wherein irrigation is both necessary and convenient, so it is used frequently.

Irrigation agriculture, while less prevalent, is also important in other parts of the state. For example, a local hub of irrigation agriculture is centered around Audrain County in the northeast corner of Missouri, and another one has developed in the counties of the Springfield Plateau. Irrigation is also important in the Missouri River valley.

Like the counties in the Bootheel region, counties in the Missouri River valley have easy access to groundwater in the alluvial soils of the flood plain. As in the Mississippi River floodplain, the water table is near enough to the surface that extraction costs are low and sup-



Source: DNR Major Water Users Database

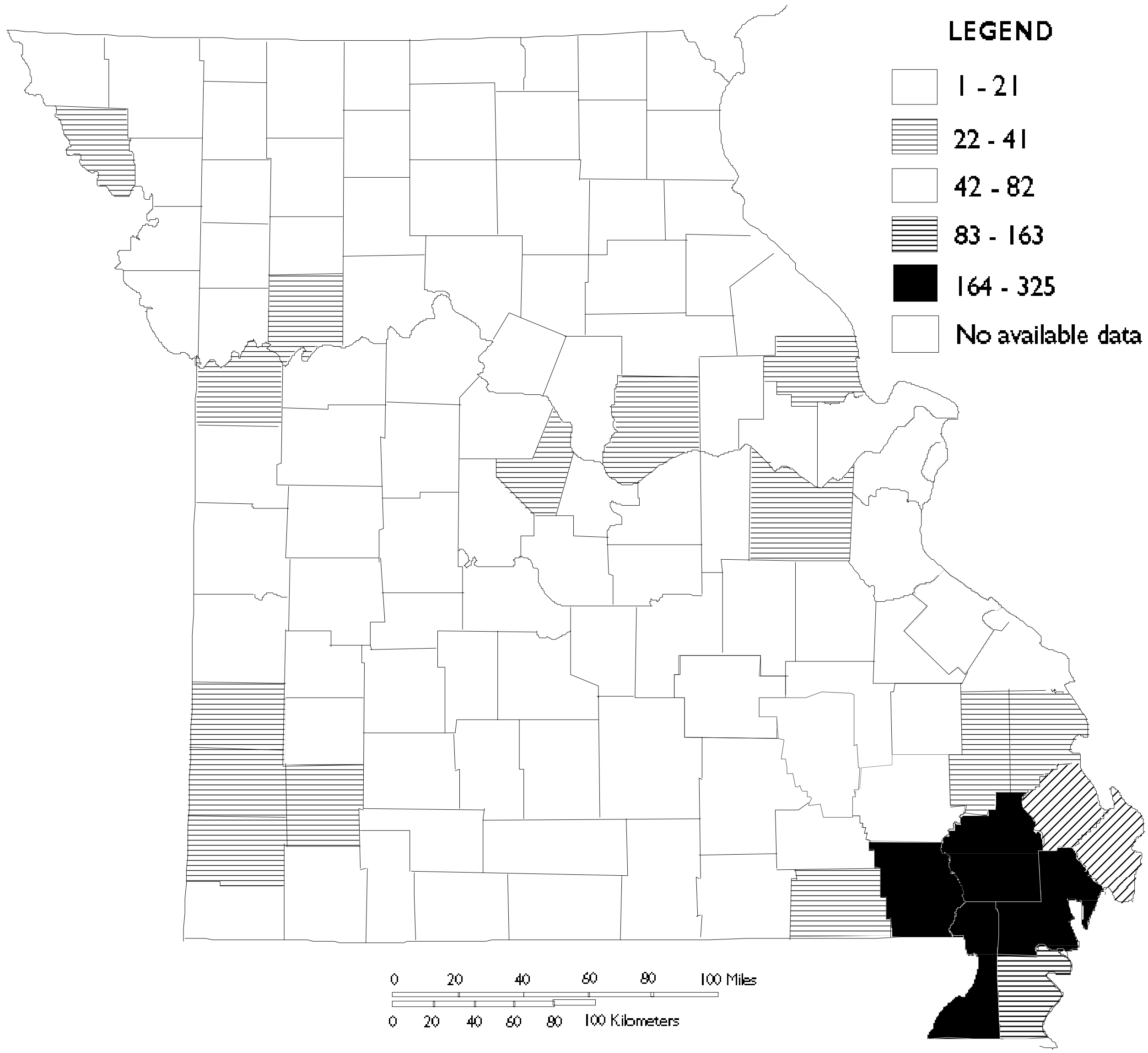
Figure 19. Irrigation water use in Missouri, 1993

plies are plentiful. As a result, irrigation again provides a simple and relatively inexpensive supplement to precipitation when it is needed (Don Pfost, personal communication, 1995).

While drought-prone soils, favorable topography and poor climatic conditions make the use of irrigation in these regions practical, promotion of irrigation as an effective agricultural practice also plays a significant role. Improvements in irrigation technology and availability have increased public awareness of the benefits of irrigation and broadened its appeal. In addition, the long history of irrigation in several Missouri counties contributes much to its continuing use.

Irrigation agriculture is important in highly urbanized St. Louis County. While conventional irrigation agriculture can be found in outlying areas of the county, irrigation in the urbanized areas can be attributed to the maintenance of urban recreational lands (such as athletic fields and golf courses), general produce and sod farming, and the operation of greenhouses and nurseries. In an urbanized area like St. Louis County, irrigation has important applications outside of agriculture, which reflects its broad social value.

Irrigation agriculture in Missouri is noteworthy for where it is not found. In more than 25 counties of northern Missouri, irrigation is



Source: 1992 U.S. Census of Agriculture

Figure 20. Farms practicing irrigation, 1992

used infrequently. It is an extensive region, stretching from Nodaway County in the northwest to Clark County in the northeasternmost corner of the state, and as far south as the Missouri River. In the northernmost counties, groundwater suitable for irrigation is much less available. Yields are among the lowest in the state. Irrigation is also uncommon in the Ozark subregion, both in the Salem Plateau and in the St. Francois Mountains. The topography and geology of the Ozark subregion often limits the agricultural viability of the land to livestock production.

CHARACTERISTICS OF IRRIGATION WATER USE

Irrigation water use in Missouri is almost entirely agricultural in application. Characteristically, irrigation water use is seasonal in nature. It is nonexistent during winter months and normally employed only during the growing season. The amount of water needed, and

the frequency of its application, depends upon the soil, the crop, and the weather. Of these three, soil characteristics and crop types tend to remain constant. From a practical standpoint, therefore, changing climate conditions is the one factor that determines whether or not irrigation will be needed.

Once the growing season starts, irrigation water use does not remain constant and it is applied only if the amount provided naturally by rainfall is inadequate. Prolonged drought can make irrigation indispensable; abundant rainfall, in many cases, may make it unnecessary. As a result, the timing of irrigation varies not only with the seasons, but also with the occurrence of rainfall.

Water quality is an important consideration in irrigation water use. In practice, the total quantity of dissolved solids found in irrigation water determines its quality. In essence, soil can be damaged by the sodium found in irrigation water. Excessive sodium makes soil less permeable, and has the effect of tightening or sealing the soil. Over an extended period of time, the productivity of irrigated lands can be substantially impaired if water quality is not adequately monitored.

The quantity of water required for irrigation is an important attribute of irrigation water use. In the 1993 DNR Major Water Users Database, only electrical generation and municipal water users reported the use of more water than irrigators. To be effective (especially in periods of drought), irrigation requires a considerable supply of water to be readily available when needed. The extensive use of irrigation in the Bootheel region, as well as the primary crop types grown there, ultimately stems from the vast reserves of water held in its alluvial soils.

The success of any irrigation project rests not only on the availability and quality of water, but also on the irrigator's ability to deliver the necessary amount of water to their fields. Unless storage facilities, wells and distribution mechanisms are constructed to deliver the quantity of water needed to maximize plant growth, the continuing success of the system cannot be ensured. Facilities and equipment must be equal to the demands placed upon them by the irrigator, and they must be extremely durable. Irrigation is seldom undertaken as a short-term solution. If irrigators are to meet the system's construction and operating expenses over a long period of time, equipment must be built with long life and low operation and maintenance costs in mind.

CONSUMPTIVE USE VERSUS RETURN FLOW

Irrigation is a highly consumptive use of water. The USGS has estimated that 73 percent of the water used by Missouri irrigators is "consumed." This is largely due to application methods currently being employed. Waters used to irrigate crops are especially subject to evaporation. Many common methods of irrigation distribute moisture by spraying small droplets of water through the atmosphere, causing a higher evaporation rate. Because irrigation is primarily employed during periods of low humidity, moisture from irrigated land moves very easily into the atmosphere. Water is also lost during conveyance from its source to the crops. Water can leak through joints in irrigation lines, or seep from ditches into the groundwater.

Nationwide, recent USGS estimates indicate that 20 percent of the water withdrawn for irrigation is lost in conveyance. Not all the water that is applied to field crops is consumed. Some of it leaves the field and either returns to a nearby lake or stream, or contributes to groundwater recharge; water re-entering the water system is called "return flow." The 1990 USGS water use report indicates a freshwater consumptive use of 269 million gallons daily (with no reported conveyance losses for the state of Missouri), and return flows amounting to 102 million gallons per day statewide. In other words, 73 percent of the water used in irrigation was removed from the immediate "water environment," and the remaining 27 percent re-entered the system as return flow (figure 21).

IRRIGATED CROPS AND ACREAGES

Missouri's irrigation agriculture industry provides an exceptionally wide range of crops to both Missouri and the United States. In terms of acreage, the largest crops irrigated by Missouri farmers are corn, and single- and double-crop soybeans, which account for over 60 percent of the total farmland currently under irrigation (table 5). In the Bootheel region, rice and cotton are irrigated extensively, and account for another quarter of Missouri's irrigated farmland. A list of agricultural products cultivated by Missouri's irrigators (and the total acres irrigated for each) is provided in table 5.

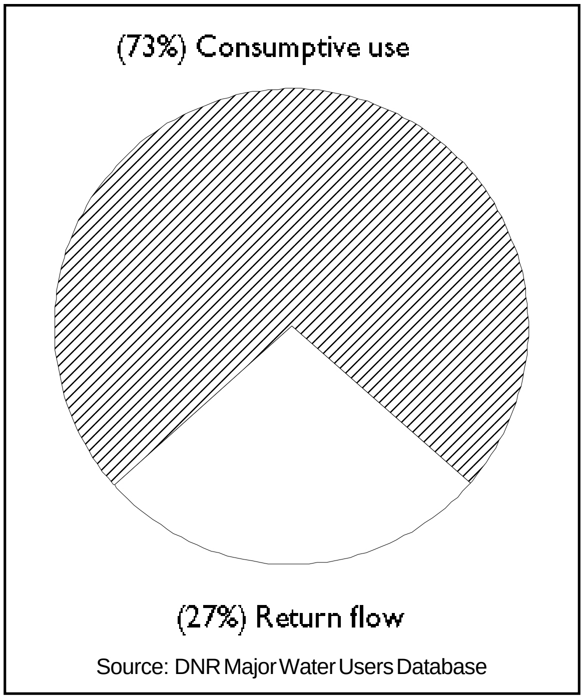


Figure 21. Consumptive use and return flow in Missouri irrigation, 1993

TABLE 5
Estimated Irrigated Acreage in Missouri
(by crop)
1994 Irrigation Survey, *Irrigation Journal*, January/February 1995

Crop	Acres
Soybeans	238,000
Corn	237,000
Rice	127,000
Cotton	52,000
Sorghum	38,000
Potatoes	8,000
Cucumbers	6,000
Vegetables	4,500
Pasture/Hay crops	3,000
Wheat	3,000
Alfalfa	2,400
Sod	1,200
Nursery	1,200
Small fruits fruits/nuts	1,200
Tree fruits	1,000
Grapes	1,000
Grass Seed	250
Tobacco	200
Peanuts	50

THERMOELECTRIC POWER WATER USE

INTRODUCTION

Thermoelectric power plants, unlike hydroelectric power facilities, rely upon a variety of fuels to produce electricity. While petroleum, natural gas and nuclear fuels all contribute to the production of electricity in Missouri, more than four-fifths of the electricity used is produced by coal-fired power plants. The Missouri Statewide Energy Study performed by the Environmental Improvement and Energy Resources Authority (EIERA) notes that coal accounted for 82.2 percent of the 1990 net electrical generation in Missouri by fuel type, followed by nuclear fuels, hydropower, and natural gas (figure 22). (Petroleum and other fuel types which produce less than half of one percent of Missouri's electrical generation are not shown in figure 22.) Despite supplying such a small fraction of the state's power needs, however, these kinds of generators often serve as important sources of emergency power (for hospitals and other critical institutions) and should not be discounted when evaluating water use. Given the dominance of coal as an energy source, however, thermoelectric water use can be reliably examined as an outgrowth of the operation of coal-fired power plants.

DEFINITION OF THERMOELECTRIC WATER USE

As noted previously, the Department of Natural Resources collects all water use information associated with power production (thermoelectric as well as hydroelectric) under the Electrical Generation water use category. The USGS distinguishes thermoelectric water use from hydroelectric use; it further splits thermoelectric water use into fossil-fuel, nuclear, and geothermal power production subcategories.

Missouri has no geothermal power production facilities. It does, however, have several fossil-fuel power facilities and one nuclear power plant (Union Electric Callaway Plant, near Fulton). In this report, "thermoelectric water use" is defined as water used in the production of electric power generated through the expenditure of fossil and nuclear fuels.

SOURCES OF WATER FOR THERMOELECTRIC POWER PRODUCTION

Water used in the production of thermoelectric power in Missouri comes almost entirely from surface water sources. Of the nearly 1.9 trillion gallons of water reported as thermoelectric water use in 1993, 99.78 percent was withdrawn from Missouri lakes and rivers. Although several reservoirs in the state supply water for thermoelectric power production needs, the Missouri and Mississippi rivers account for almost all of Missouri's thermoelectric water use. Of all reported surface water withdrawals for thermoelectric use, 88.4 percent are taken from these two sources (figure 23).

Steam Generation

To produce electricity, coal-fired power plants use water in two important processes—steam generation and steam condensation.

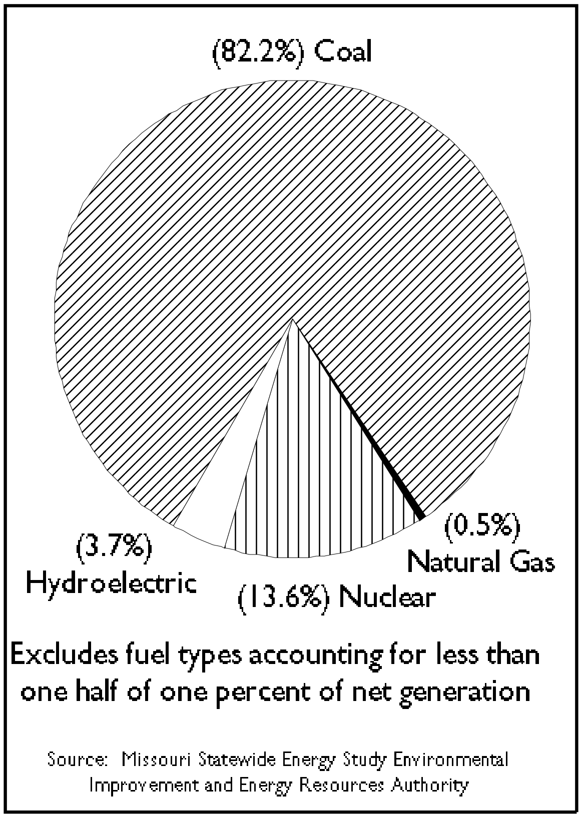


Figure 22. 1990 Total annual net electric generation in Missouri, by fuel type

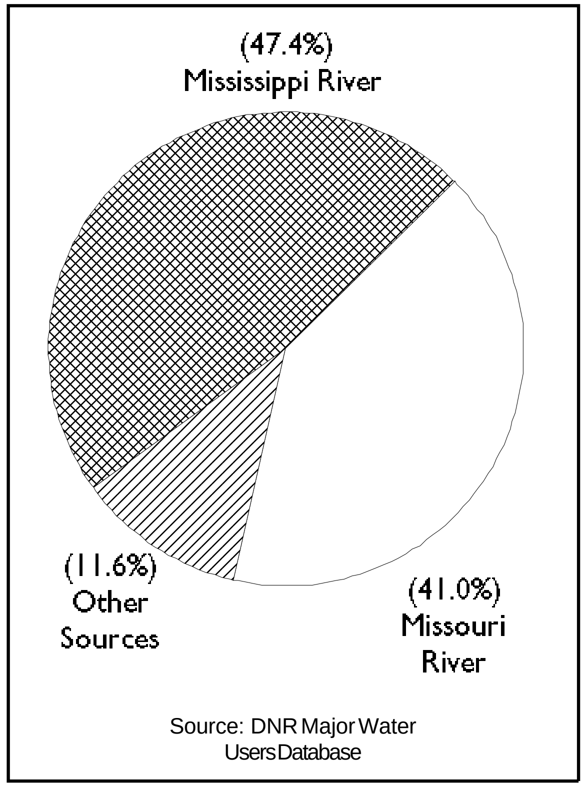


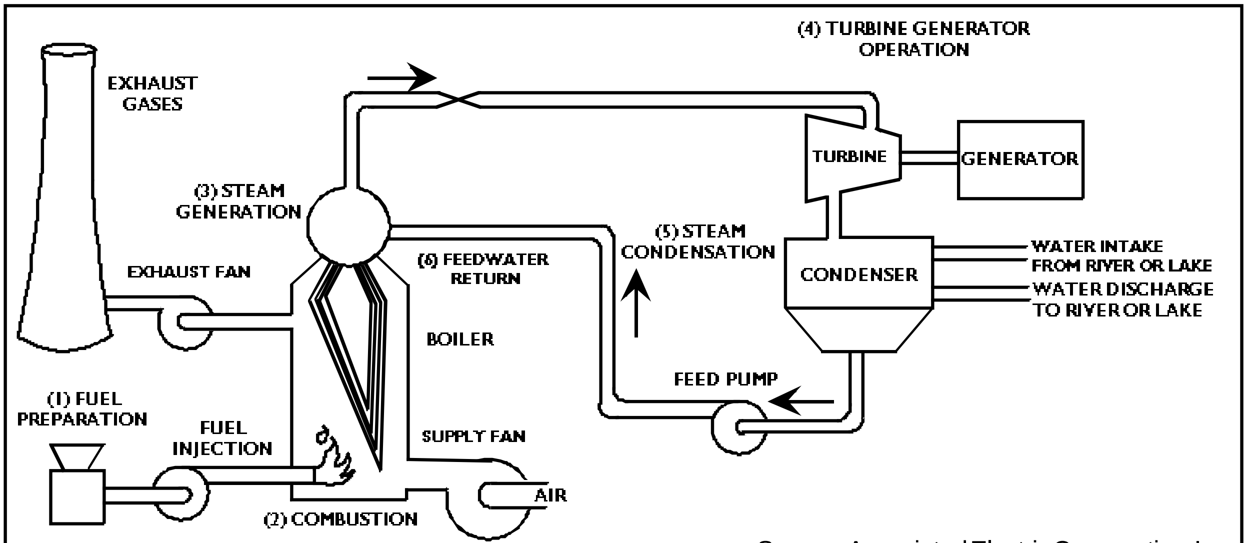
Figure 23. Surface water sources used for thermoelectric power generation, 1993

Coal-fired facilities operate by generating steam from liquid water, which is driven through turbines to produce energy. The turbine, in turn, is connected to a large electromagnet that revolves within a wire spool. As the turbine revolves, the electromagnet also turns and the lines of magnetic force produce electricity as they "cut" the wire. Typically, the steam used to generate electricity in this fashion is continuously recycled. As it is converted to steam, the water passes through the turbines. It then passes into the condenser (the central component of steam condensation), where the water returns to a liquid state and is recirculated back to the boiler (figure 24). The amount of water required to generate steam in modern thermoelectric facilities can be substantial; many currently operating turbines are capable of passing steam flows of several million pounds hourly. However, the water used in steam generation is continuously used and reused, and very little of it is actually consumed.

Power Plant Cooling

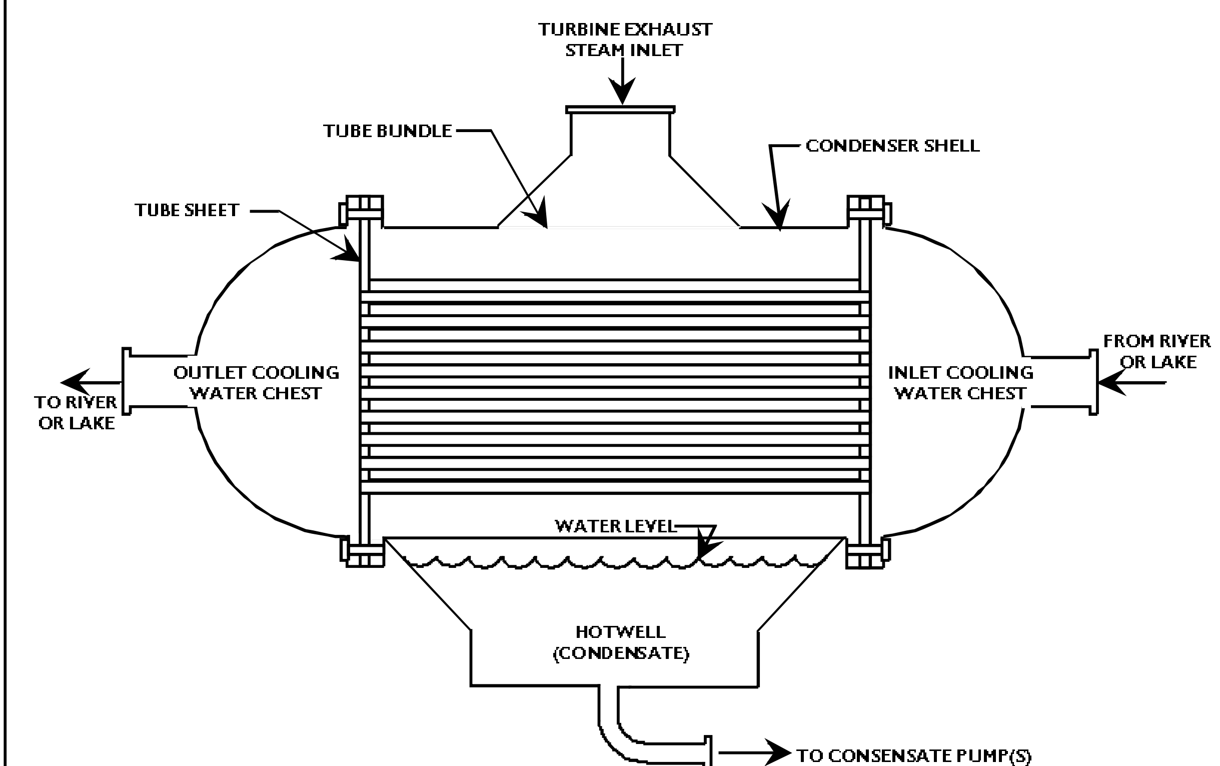
Just as the burning of fuel is needed to create steam for power generation, cooling water is required to return the steam to liquid form. Returning the steam to its liquid state (rather than venting it off) allows the high quality feedwater to be reused; it also helps maximize power plant efficiency by reducing backpressure on the turbine blades.

The process of returning steam to liquid water is referred to as "steam condensation." The steam condensation process removes heat from the steam, returning the steam to its liquid state. In the condenser, cooling water is run through thousands of small metal tubes, which come into contact with the steam leaving the turbines (figure 25). As the hot steam comes into contact with the water-cooled pipes, the steam condenses. In essence, the heat of the steam is absorbed by the much cooler water running through the condenser. As the steam condenses, water is collected in the bottom of



Source: Associated Electric Cooperative, Inc.

Figure 24. Basic schematic of a fossil fuel power plant



Source: Associated Electric Cooperative, Inc.

Figure 25. Basic schematic of a condenser unit

the condenser and circulated back to the boiler. The cooling water flowing through the condenser, after cooling to an acceptable temperature, is routed back to the river or lake from which it was originally taken. The amount of water required to operate a condenser unit can be quite large; a typical generator may circulate several hundred million gallons of water during daily operations.

Because large quantities of surface water are so readily available in Missouri, the most common method of power plant cooling used in the state is known as "once-through" cooling. In this process, water is diverted from its source (typically a large river or lake capable of providing large volumes of water) and circulated through the condenser. Heat is transferred from the boiler water to the cooling water through contact with the condenser pipes, and is carried off to the point of discharge. To accomplish this effectively, the temperature of the incoming cooling water must be low enough to "absorb" the waste heat in the boiler water. As a result, water temperature is an important aspect of thermoelectric water use (see CHARACTERISTICS OF THERMOELECTRIC WATER USE, page 43).

Another method frequently employed for power plant cooling involves the use of cooling towers. Most cooling towers fall into one of two categories—wet or dry. Wet cooling towers cool water primarily through evaporation as water falls from the top of the tower to the collection basin below. Fill material within the tower divides the water into small droplets, enhancing evaporation. As a result, more water is evaporated from wet cooling towers on the basis of volume than from once-through cooling, hence the increased consumptive use of the cooling water. Dry towers, on the other hand, operate in a fashion similar to the radiator found in an automobile. The heated water contained in the tower is never directly exposed to the cooling air. Because of the large volumes of water required to provide once-through cooling, dry cooling towers are quite often constructed in arid regions, such as the western states, to economize water use. The use of dry cooling towers may be increaseing in more eastern states because of increasing demand for water. Because they use less water than wet cooling towers (and much less than once-through cooling processes), they are unable to transfer as much heat and are therefore less efficient thermally. To perform comparably, dry cooling towers are more expensive to own and operate than wet cooling towers.

THERMOELECTRIC WATER USE VOLUMES

Both the 1993 Major Water Users Database and USGS circular 1081, *Estimated Use of Water in the United States in 1990* estimate that thermoelectric power facilities in Missouri use nearly 1.9 trillion gallons of water yearly. As the two largest providers of water for thermoelectric water use, the Missouri and Mississippi rivers supply 774.5 and 896.5 billion gallons of water annually. The remaining 11.6 percent of Missouri's thermoelectric surface water supplies come from a number of man-made lakes throughout the state, such as Thomas Hill Reservoir in Randolph County.

Only 4.2 billion gallons of groundwater were reported used in Missouri for thermoelectric water needs in all of 1993. The 1993 estimate underscores the importance of the Missouri and Mississippi rivers for thermoelectric power water use; this amount of water is diverted from (and returned to) the Missouri River to meet thermoelectric water requirements every two days.

Although this discussion of thermoelectric water use has centered almost entirely around coal-fired thermoelectric plants, nuclear power has a presence in Missouri which should not be ignored. Missouri's sole nuclear power facility, the Callaway Nuclear Power Plant located near Fulton, produces a significant amount of energy for the state. Reported 1993 water use for the Callaway Plant exceeded 7.8 billion gallons of water. Like many coal-fired power plants, the water used at the Callaway facility is withdrawn from the Missouri River.

CHARACTERISTICS OF THERMOELECTRIC WATER USE

The Missouri and Mississippi rivers are able to provide large quantities of water throughout the year to thermoelectric water users under most conditions. Both rivers, as well as a number of man-made reservoirs statewide, are ideal sources of water for once-through cooling systems. Most of Missouri's thermoelectric power generators take advantage of this, relying upon once-through cooling systems in their plant operations. Consequently, year-round use of large water volumes has become a fundamental characteristic of Missouri's thermoelectric water use.

Thermoelectric power facilities do not experience the daily and seasonal fluctuations encountered by hydroelectric power facilities and therefore, even though the two types of facilities apply their output to the same electrical demand curve, they do not share similar water use characteristics.

Thermoelectric power plants are designed to run constantly, once started, and to generate baseload power to meet the minimum around-the-clock demand for electricity. Once power generation begins, water use at a thermoelectric power plant tends to remain constant. Some thermoelectric power plants, however, do provide power to meet peak demand (see also HYDROPOWER WATER USE IN MISSOURI). Those that do, operate similarly to baseload plants but are smaller in size and often have higher fuel costs.

Water quality is an important characteristic of thermoelectric power water use. Impure boiler water can cause scaling on (or corrosion of) piping and interior boiler surfaces. Excessive amounts of silica in boiler water, if not removed, may damage turbine blades. To protect against damage, thermoelectric facilities use treated boiler feed-water. Chemicals, such as lime and ferric sulphate, can be added to reduce suspended solids in boiler water. At small levels sulphuric acid helps prevent scaling and corrosion. As with hydroelectric power facilities, thermoelectric power plants prefer to operate as efficiently as possible. But to achieve optimal performance, boiler water must be exceptionally pure. In fact, one of the most important functions of the condenser unit is to allow thermoelectric facilities to use and re-use treated boiler water.

Water quality is also important to power plant cooling. As might be expected, the temperature of incoming cooling water affects the operation of any thermoelectric power facility using "once-through" cooling. If temperatures are too high, the cooling water will be less able to "absorb" the waste heat of the boiler water. Under certain conditions, source water temperatures may be high enough to negatively affect the efficient operation of the facility.

Efficiency can also be reduced by algal and bacterial growth on the inside surfaces of condenser tubes. Water temperatures in the warmer months of the summer are optimal for the growth of these organisms. If preventative steps are not taken, algal and bacterial growths act as heat insulators and restrict the flow of cooling water.

CONSUMPTIVE USE VERSUS RETURN FLOW

Steam condensation is a consumptive use of water. The quantity of water "consumed" in power plant cooling depends upon the cooling process. Once-through cooling dissipates heat through increased evaporation from the slightly warmer water leaving the power plant. Power plant cooling through the use of cooling towers is a more consumptive cooling procedure than once-through cooling on a "pound-for-pound" basis. Typically, the water warmed by the power generation process is evaporated through exposure to air (induced either naturally or artificially), thus cooling the remaining water.

Water use by nuclear plants tends to be slightly more consumptive than use by coal-fired plants. Circular 703, *Water Demands for Expanding Energy Development* published by the USGS, indicates that the "typical" fossil-fuel process operating at peak efficiency consumes 0.5 gallons of water per kilowatt/hour, compared to 0.8 gallons used in nuclear power production.

Current water use reporting in Missouri provides specific information on the consumptive use of water used in thermoelectric power generation. In addition to reporting total water use, each major water user is also asked to provide information on the amount of water "returned" after use. While the quality of reported return flow data varies according to water use category, return flow information obtained from electrical power generators is believed to be accurate.

In 1993, reporting electrical generators extracted nearly 4.2 billion gallons of water from Missouri groundwater sources. Because convention dictates that return flows include only water returned directly to its source, generators using groundwater released to surface waters after use reported no return flow. Those taking water from surface water sources reported extracting 1.89 trillion gallons and returning 1.88 trillion gallons to the water environment, a consumptive use of approximately 10 billion gallons. Both the USGS and the DNR Major Water Users Database agree that, as a proportion of total withdrawals, little water is actually consumed in the thermoelectric power generation process. Return flows reported by Missouri's thermoelectric power generators have been estimated at 97.9 percent and 99.2 percent of total withdrawals, respectively.

IN-STREAM WATER FLOW AND ITS USES

INTRODUCTION

In-stream flow refers to the quantity of water, and its variation over time, as it exists in a watercourse. This can also be referred as the flow regime of the watercourse.

In-stream flow of most watercourses serves a purpose be it human uses, survival of organisms, or changes in the earth's surface. Maximum, minimum, and average quantities of stream flow, how often these quantities occur, the duration of their occurrences, and the time of the year that various stream flows occur, can be important factors in meeting the needs of in-stream flow uses.

Some in-stream flow uses in Missouri include:

Hydroelectric power production
Commodity transport
Recreation
Channel maintenance
Transport of effluent discharges
Protection of aquatic organisms

PARAMETERS OF IN-STREAM FLOW

DISCHARGE

A popular parameter of water quantity in watercourses is rate of flow, i.e., discharge, which is an expression of water volume moving past a specific location per unit of time. Common units of measure in Missouri are cubic feet per second (CFS), gallons per minute (GPM), million gallons per day (MGD), and acre feet per year (ACFT/YR). For example, the average discharge of the Missouri River at the USGS river gage in Kansas City for the period of record 1928-1993 is 50,850 CFS; 22,823,056 GPM; 32,865 MGD; and 36,813,719 ACFT/YR. Appendix 5, Table 1 presents 280 gaging stations throughout the state in alphabetic order of the gage location name. Long term monthly and annual average stream-flows are presented. Appendix 5, Table 2 presents those same gaging stations in numeric order of the gaging station USGS identification number. Appendix 6 illustrates locations of the gages.

STAGE AND ELEVATION

Uses of "in-stream flow" often require quantities of water sufficient to occupy the watercourse up to a specified level. This is commonly referred to as stage or water surface elevation. Stage is expressed in vertical units (meters, feet, etc.) greater than the elevation of a reference point at a specific location in the watercourse. Water surface elevation is usually expressed in vertical units (commonly feet) above sea level. For example there is a stream gage on the Nodaway River in northwest Missouri 0.15 miles east of the town of Maitland in Holt County. The gage has been in operation since 1982. The maximum stage recorded by that stream gage is 26.16 feet, which is equivalent to a water surface elevation of 878.25 feet above sea level. Most stream gage data in Missouri is collected by the U.S. Geological Survey. This type of data can be accessed from a variety of sources. The data is published annually on CD-ROM and in a book titled *Water Resources Data, Missouri*. Some of the information is accessible via the Internet.

Water uses with this basic requirement often utilize the buoyancy or energy in that water. Examples are hydropower generation,

commodity transport, and recreation. Other uses requiring specific stages utilize the mere presence of water at the specific stage or elevation such as water withdrawal intakes to provide water for irrigation, livestock watering, drinking water treatment facilities, or the cooling of thermal power generation facilities.

Velocity

Stream flow velocity is an important factor for some in-stream uses of water. Many species of fish use moving water habitat within a limited range of velocities. Stream flow velocity is a measure of the speed of the water as it moves past a location in the watercourse. Velocity has wide variation within the cross section of a watercourse. Velocity may be the fastest in the main channel of a watercourse and the slowest at the banks of the watercourse. In Missouri, stream flow velocity is often expressed as linear feet per second. For example, stream flow velocities in the main channel of the Missouri River at Kansas City during normal flow conditions are approximately 3 to 5 feet per second.

Timing

Many in-stream flow uses occur only during predetermined time periods, often with cyclic patterns of use ranging from daily cycles to annual cycles. Flora and fauna uses often occur in annual cycles. For example, stream fishes usually require higher flow rates during the spring and fall for spawning. Hydropower generation facilities use water in cycles. Electricity use has a daily occurrence of peak demand (approximately 3 PM) and seasonal occurrence of peak demand (during annual high and low ambient air temperature extremes). Commodity transport on the Missouri River is managed as a seasonal use by sustaining adequate discharges from April to November.

An important factor in determining the adequacy of in-stream flow for a water use is the variability of stream flow over time compared to the variability of water use over the same period of time. This can be especially important during periods of low flow conditions. During these periods demand for water is highest among some water uses and availability of water is lowest. Conflicts among water uses can arise. It is important to know how much water will be available during periods of low flow.

Low Flow

Low flow is a description of stream flow at minimal magnitudes for a watercourse. Base flow is stream flow occurring in the absence of storm runoff (usually periods of little or no precipitation) and is usually comprised mainly of water from subsurface contributions. Low flows in a watercourse without reservoirs to store water and release it gradually, often approximate the base flow of that watercourse. Low flow regimes are often described in terms of base flow.

Low flow regimes have regional characteristics related to physiographic regions in Missouri. Base flow in the Plains region is low due to low storage capacity of shales and clays in the region. In the Ozark Plateaus region, springs contribute substantially to base flow and provide the highest base flow in the state due to the soluble carbonate geology throughout the plateaus. There are exceptions to this general abundance of base flow in the Ozark Plateaus region. Underground solution cavities forming karst topography can create conduits for water to exit surface stream channels, and enter underground systems, resulting in diminished base flow in overlying watercourses. These are commonly referred to as “losing streams.” The Southeast Lowland region has high amounts of surface water contributing to stream flow during times of insignificant precipitation and is less dependent on base flow to maintain stream flow during low flow periods.

DETERMINING IN-STREAM FLOW REQUIREMENTS

Many in-stream flow uses are not mutually exclusive. In-stream flows that benefit one use may also benefit other uses to some extent while also conflicting with other uses. However, regulating in-stream flows to maximize the benefits of a specific use may often reduce benefits to other uses of that water. An impor-

tant factor in managing in-stream flows is to balance the water use needs of all users and uses. This is commonly attempted with the following steps: Determine the needs of each water use; compare the needs of each use with that of the other uses; determine which needs conflict with one another; and develop a compromise that provides desired in-stream flows to an equitable extent among all the in-stream flow needs.

Some uses of in-stream flow can readily determine exactly what the in-stream flow requirements are. Hydropower electrical generation water use can be calculated accurately by applying physics and fluid mechanics equations to the desired amounts of electricity to be generated (see Hydropower section in this report). Hydropower electrical generation dam facilities are required by the Federal Energy Regulatory Commission (FERC) to maintain water releases from the dam with flow rates greater than a specified minimum. This requirement contributes to assuring in-stream flows will be adequate for maintaining water uses of the river downstream of the dam. Section 6, Hydropower, in this report presents hydropower facilities in Missouri.

Commodity Transport water use can be calculated by measuring or calculating the river discharge that will create the water depth and width required for commercial vessels to navigate the watercourse. For example, on the Missouri River (an extensively regulated watercourse), assume that a minimum water depth of nine feet and a minimum width of 300 feet are required to allow commodity barges to navigate the river for eight consecutive months out of a year. At Kansas City, a nine-foot water depth with 300-foot width in the Missouri River can be maintained with a discharge of approximately 41,000 CFS. Maintained for eight consecutive months, 41,000 CFS adds up to approximately 29,666,380 acre feet (ACFT). Under this scenario the annual water use demand for an eight month season of barge trafficking on the Missouri River at Kansas City would be 29,666,380 ACFT/YR.

Recreational watercraft have minimum water depths and widths required to make it possible for the craft to navigate through the watercourse. Table 6 shows required depths and widths for various recreational watercraft. With this information, in-stream flow needs for recreational watercraft on a specific stream reach can be calculated with measurement of its geometry and stream flow. Hydraulic calculations can be made to determine how much water needs to flow through the watercourse to obtain the required water depths.

Table 6
Required Stream Depth and Width for Various Recreational Craft.

Recreational Craft	Required depth (ft)	Required width (ft)
Canoe-Kayak	0.5	4.0
Drift boat; rowboat, raft	1.0	6.0
Tube	1.0	4.0
Power boat	3.0	6.0
Sail boat	3.0	25.0

Source: In-stream Flow Information Paper No. 6 (R. Hyra, 1978)

Channel Maintenance

Alteration of the flow regime can have a significant affect upon channel characterisics. Components of the flow regime important for maintaining existing characteristics are often termed channel maintenance flows. These are discharges that contain energy great enough to effect the geometry and configuration of the channel. Physical characteristics of the channel that may change include channel geometry (width, depth, gradient) and channel pattern (sinuousity, braiding, anabranching).

Channel maintainence flows tend to occur as hydrologic events as opposed to continually. During periods of time between these events the lack of channel-altering energy allows the occurrence of natural processes such as siltation upon substrates and terrestrial veg-

etative growth low in the channel. The latter normally exists only until removed by the next high energy flow event. The occurrence of channel maintainence flows and the lack thereof are natural cycles. When the cycles are unnaturally altered, detrimental affects may be experienced. The impacts of these changes can be rapid channel migration in unsuspected directions and channel downcutting, both of which can destroy property and necessary utility structures. Aquatic and riparian habitat can be impacted to the extent that plant and animal species are rooted or driven from the watercourse.

Detecting the changes in channel maintenance flows requires knowing the past and present channel maintenance flows of a watercourse. Geomorphic studies have found that peak flows, with a recurrence interval of approximately 1.5 to three years may have the most significant effects upon natural river channels in the United States. Peak flows (peak discharges) with extremely long recurrence intervals have impacts that are perhaps the most noticeable to humans and have significant effects on the flood plain. The record floods of 1993 are a prime example. Recorded data of peak flows with the longest recurrence interval are peak flows for the period of record of the stream gage of interest. Table 7 contains peak flows with 1.5 year recurrence intervals, three year recurrence intervals, and the peak flow for the period of record at stream gages on nonregulated watercourses in Missouri. A watercourse is nonregulated if it has no control structures.

Changes in the physical characteristics of a watershed can alter flow regime components. In Missouri the most common cause for such changes is how land is used by humans.

TABLE 7

1.5 yr., 3 yr., and maximum discharges (cubic feet per second) at selected stream gages

Station Name/ID	**1.5 Yr. peak flow**	**3 Yr. peak flow**	**maximum flow**	**period of record**
Grand River near Sumner/6902000	59,550	76,500	180,000	1923-1993
Fox River at Wayland/ 5495000	6,510	9,938	26,400	1922-1993
Little River Ditch near Lilbourn/7042500	2,650	3,530	6,580	1946-1991
Shoal Creek near Joplin/7187000	7,740	12,600	62,100	1924-1993
Lamine River near Clifton City/6907000	12,640	23,060	90,000	1905-1980
Platte River near Agency/6820500	18,200	24,600	60,800	1924-1993

Reducing infiltration rates of precipitation in a watershed alters its flow regime by decreasing base flows and increasing peak flows. Many communities experiencing significant development have seen flooding become worse than it had been previously. Development activities usually create impervious surfaces on land that formerly were pervious. An impervious surface prevents water from entering into the ground. Rainfall upon impervious surfaces will either evaporate into the atmosphere or run off and quickly enter watercourses, as opposed to penetrating the ground and slowly moving toward watercourses. Increased flooding is often the result. Figure 26 presents the calculated results from various percents of impervious land area in a hypothetical 20-square mile watershed experiencing the 25-year flood. Increases in percent of impervious area from one to ten percent would create a 35 percent increase in peak flow. Increases in percent of impervious area from one to 25 percent would create a 52 percent increase in peak flow.

The rainfall that previously entered the ground of the pervious land areas often was the major source of water for stream flow that existed during dry times (base flow). With that water no longer contributing to base flow, the watercourse may no longer have stream flow during dry times.

Relatively low stream flow has subtle effects upon a watercourse. A common effect is terrestrial vegetative growth above the surface of the water in portions of the watercourse that would normally be inundated and have much less vegetation. Excessive vegetation can have noticeable effects on the hydraulics of water moving through the channel or the flood plain. In some situations, results can include

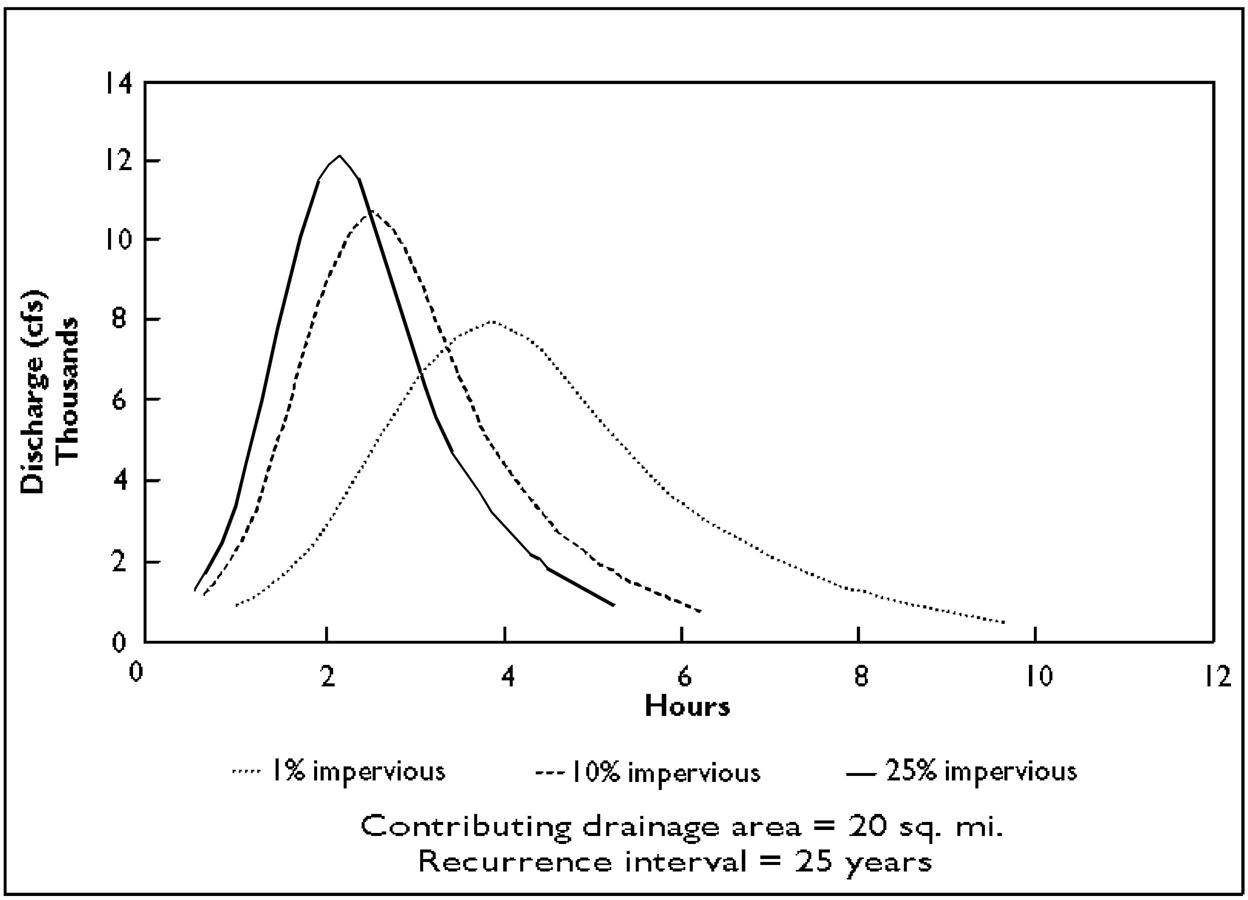


Figure 26. Hydrographs with variable impervious areas

stream bank stabilization or a wetland flourishing with an unsurpassed variety of organisms.

In other situations, the additional vegetation slows the flowing water and may act as a catch-net forming log and debris jams with debris being transported by high magnitude stream flow events. This can result in stream flow magnitudes which did not previously cause over-bank flow (flooding) now causing unexpected flooding of land that was historically above the water level.

Some adverse impacts of land use upon in-stream flows can be prevented or reversed. Hydrologic regimes can be examined to determine how much alteration has occurred, and what the preferred hydrology is for water uses of a specific portion of a river. Information gained with watershed analysis can improve the practical, economical, and political results of natural resource management decisions.

Transport of Effluent Discharges

Watercourses that receive water containing contaminants are used as transport systems for such pollutants. They have a limited ability to lower the toxicity of some pollutants. There are many factors that affect the ability of a watercourse to detoxify effluent, including the type of substrate material, water temperature, chemical content of receiving water and that of the effluent, the effluent percentage of receiving water, and the presence of organisms with biodegrading capabilities.

In-stream flow directly affects the effluent percentage of the receiving water (dilution factor) and becomes especially important during times of low flow. Effluent percentage of receiving waters is dependent upon effluent volume of water and the volume of receiving water. With effluent discharge volume remaining constant, as in-stream flow decreases, effluent percentage of receiving water increases. The result is higher concentrations of pollutants in the receiving water and potentially lower water quality in the watercourse.

This problem is addressed in the design of wastewater treatment facilities by using an expected minimum flow of the receiving water to calculate the amount of pollutants that can be released into streams without causing adverse impacts. In Missouri, this criteria is the seven-day, 10-year minimum flow of the receiving water. It is a statistical parameter that estimates the average minimum flow for seven consecutive days that have a recurrence interval of 10 years. Table 8 presents calculated seven-day 10-year minimum flows at several stream gage locations around the state.

Table 8

Seven-day 10-year Minimum Flow at Selected Stream Gages

Station Name/ID	Seven-Day Ten-Year Minimum Flow (cfs)
Grand River near Sumner/6902000	37.8
Fox River at Wayland/5495000	0.2
Little River Ditch near Lilbourn/7042000	41.4
Shoal Creek near Joplin/7187000	43.9
Lamine River near Clifton City/6907000	0.6
Platte River near Agency/6820500	3.1

A significant factor of low flows in Missouri and transport of effluent, especially in the Ozark Plateau, is the losing stream characteristics of some watercourses. As stated in the *DNR Water Quality Standards,* A losing stream "distributes thirty percent or more of its flow through natural processes, such as through permeable geologic materials into a bedrock aquifer within two miles flow distance downstream of an existing or proposed discharge. Flow measurements to determine percentage of water loss must be corrected to approximate the seven-day 10-year stream flow." A watercourse with losing reaches can experience stream flow that decreases as it moves downstream, or, during low flow conditions, ceases flow altogether.

Losing stream reaches transporting water pollutants create a direct avenue for introducing those pollutants into nearby aquifers. Groundwater contamination can ruin drinking water supplies. It creates an immense economic burden for people who rely upon groundwater resources, with minimal treatment, for drinking water. The DNR Water Quality Standards prohibit the discharge of effluent within two miles upstream of a losing stream reach. Identifying losing stream reach locations is important in any hydrologic investigation.

The Division of Geology and Land Survey continues to investigate potential losing stream reaches throughout the state. Figure 27 illustrates locations of the upstream end of stream reaches that have been determined, as of September 1995, to have losing stream characteristics. Figure 28 presents, by county, the total number of losing stream reaches and the total number of miles of losing stream reaches. Appendix 7 lists each losing stream with its length and number of losing reaches. A stream reach not appearing on this list has not necessarily been determined to be "gaining" — the stream may not have been surveyed.

The Ozark Plateau has by far the majority of identified losing reaches within the state. The counties of Barry, Green, and Christian hold approximately 39 percent of Missouri's identified losing stream reaches. Along the northeast fringes of the Ozark Plateau, Jefferson County has the fourth highest number of losing reaches, totaling 44. Howell, Dent, Shannon, and Oregon counties have relatively long total lengths of losing reaches with Howell County holding the longest total length of losing reaches (243 miles) in the state.

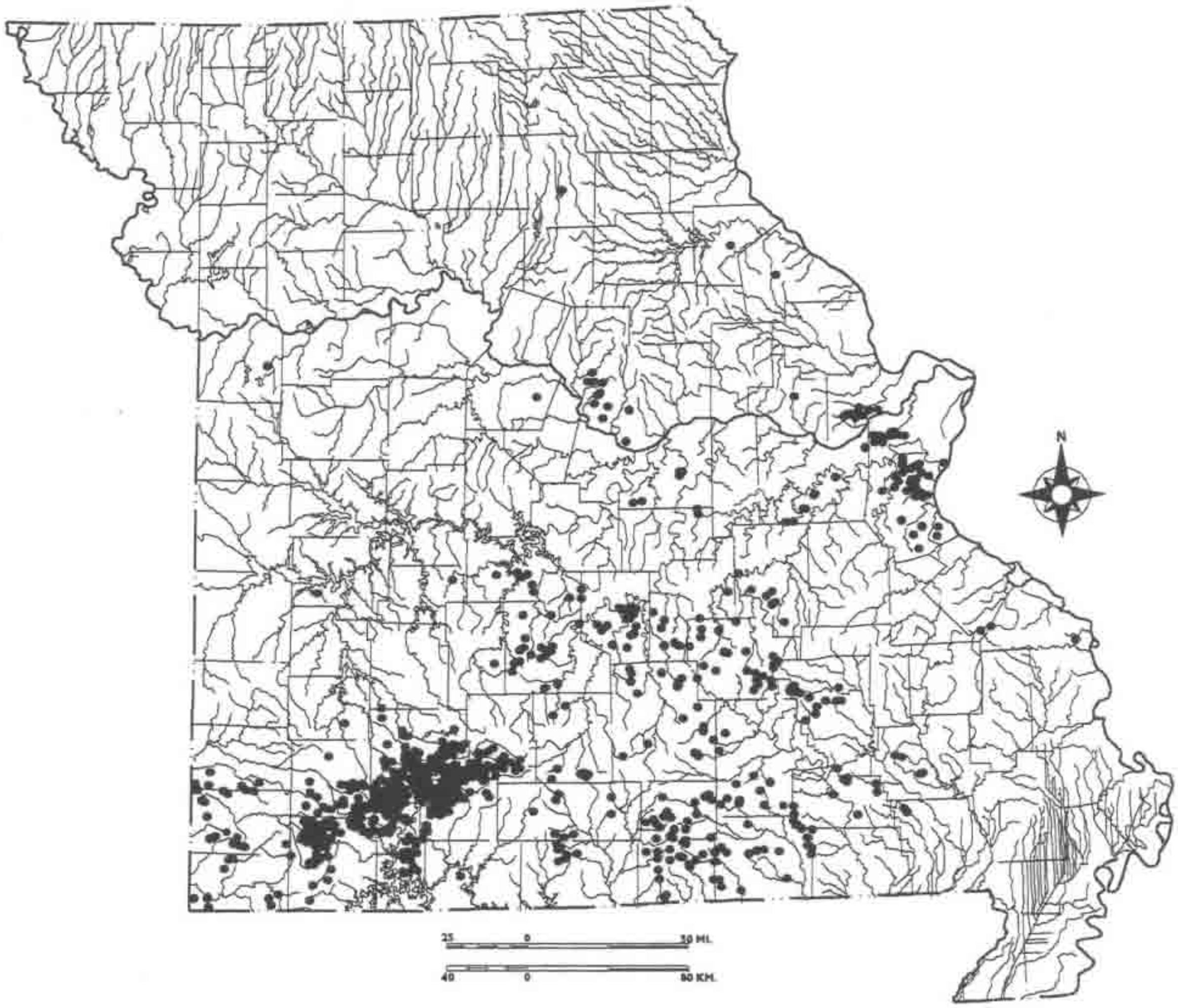
Fish and Wildlife

Perhaps the most complex standards for in-stream flow requirements are those for aquatic organisms. Many species require differing in-stream flows in order to live. Hundreds of species in Missouri are dependent upon flowing water and are usually dependent upon many other species in the same watercourse. Calculating the in-stream flow that will best meet the needs of this wide array of users requires extensive knowledge of the species existing within each watercourse.

Altering the hydrologic regime of a river can significantly impact the aquatic ecosystem in that river. Dams, reservoirs, and water diversions have significantly altered flow regimes on river systems around the world. While many benefits are received from such changes to river systems, adverse impacts are also experienced.

Methods used for determining in-stream flow requirements of aquatic life are one of three types. In order of increasing complexity, they are: (1) historical discharges or rule-of-thumb methods, (2) threshold methods, and (3) in-stream habitat simulation methods. A variety of time scales for flow requirements might be used with any of these methods, i.e., weekly, monthly, seasonal or annual. A useful source of information is historic stream gage discharge data. Appendix 5, Table 1 presents 280 gaging stations throughout the state in alphabetic order of the gage location name. Long term monthly and annual average streamflows are presented. Appendix 5, Table 2 presents those same gaging stations in numeric order of the gaging station USGS identification number. Appendix 6 illustrates locations of the gages.

The historic discharge method uses only stream flow data to define in-stream flow re-



Source: DNR Losing Stream Reaches Database

NOTE: Points represent upstream end of the losing reach. A stream reach not appearing on this map has not necessarily been determined to be "gaining"—the stream may not have been surveyed. Many stream reaches have not been surveyed for losing characteristics.

Figure 27. Losing stream reaches identified, September 1995

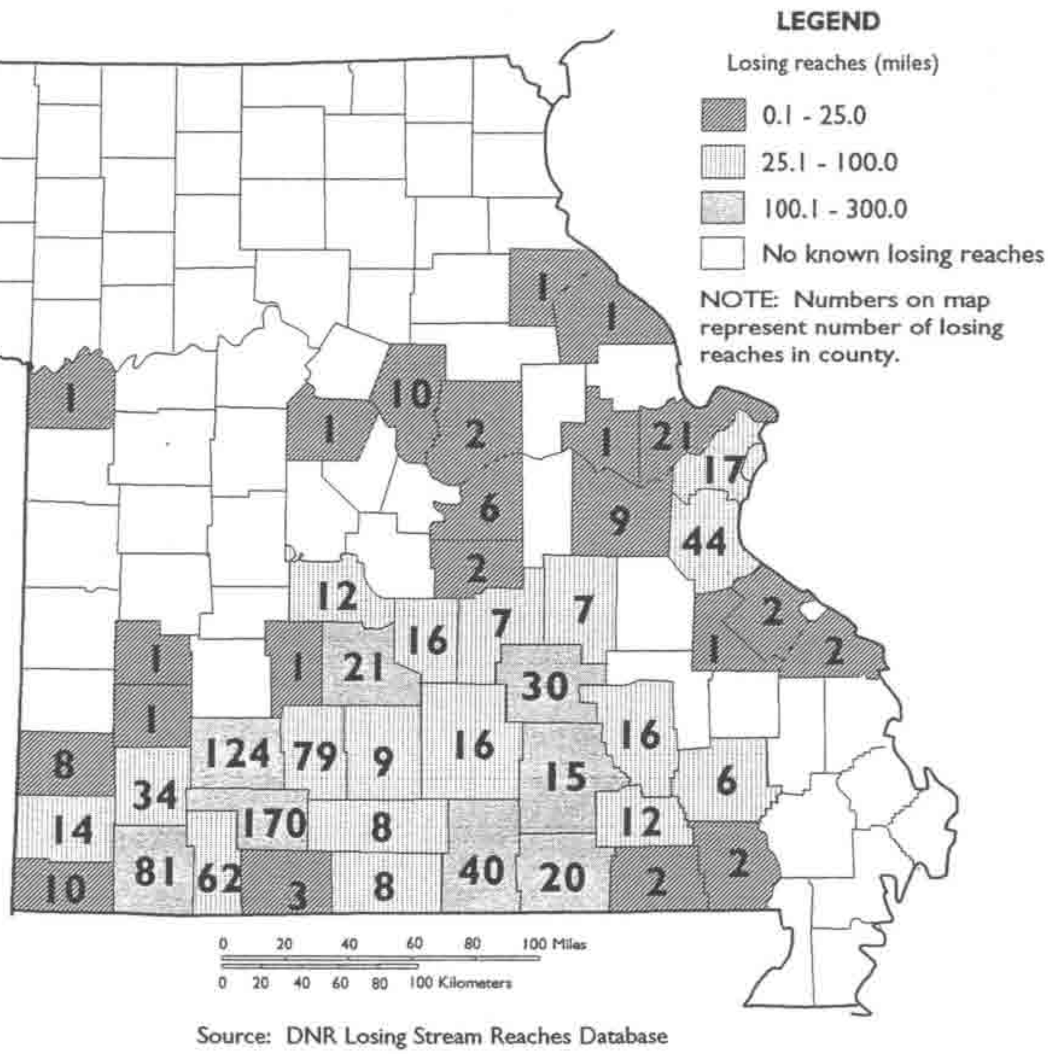


Figure 28. Losing stream reaches identified, county totals, September 1995

quirements which use statistical parameters of the flow data. The simplest of requirements at a stream location would be minimum flow expressed as a portion of the mean annual discharge at that location. An example of a historic discharge method is the Tennant method, which determined that a discharge of 10 percent of the mean annual discharge was low enough to restrict fish to deeper pools and prevent larger fish from passing through riffles in Montana, Nebraska, and Wyoming. A discharge of 30 percent of the annual discharge provided satisfactory widths, depths, and velocities of water in rivers.

A drawback to applying such statistics is that stream morphology (form and structure) is a significant factor in the effect a discharge percent will have on the resulting relative magnitude of habitat sustained by that flow. Variation in stream morphology between Missouri and that of Montana, Nebraska, and Wyoming is significant. Stream morphology variation, just within Missouri, could be significant enough to preclude the application of a statistic statewide. Prior to applying such parameters developed for other physiographic regions, stream habitat measurements and monitoring should be conducted. The Arkansas Method is an example of applying the Tennant Method to local conditions. Development of the Arkansas Method from the Tennant Method included consideration of critical life cycle stages for native Arkansas fish, seasonal flow requirements, and physiographic regions of Arkansas.

Threshold methods use information about habitat requirements for specific fish species and examine the availability of habitat for those species at various discharges. A discharge threshold is determined below which habitat is inadequate for the in-stream flow needs. Physical parameters of the watercourse are determined at critical habitat locations by measuring characteristic elements such as cross-sectional profiles, water surface elevation, velocity, and substrate type. Hydraulic analysis is conducted to determine the amount of habitat made available as a result of specified discharges. Available habitat can then be related to habitat required by a species to determine whether the specified discharge will provide adequate habitat.

In-stream habitat simulation methods are similar to threshold methods in that habitat requirements of a species are compared to available habitat resulting from various discharges. The difference between the two types of methods is that in-stream habitat simulation methods provide greater attention to changes in available habitat over a range of discharges. In-stream habitat simulation models include species-specific habitat requirements for multiple species and multiple in-stream uses. A prime example is the In-stream Flow Incremental Methodology (IFIM) developed by the U.S. Fish and Wildlife Service. This method uses multiple computer models simulating habitats resulting from incremental ranges of discharges as well as time periods and combinations of various levels of water uses. Optimum discharges for several individual species and water uses can be determined and used to recommend an operational plan for managing in-stream flow in a watercourse.

The In-stream Flow Incremental Methodology has been applied to a few stream sites in Missouri. An example is the James River in Greene County. In 1979, the City of Springfield was in need of additional sources of public drinking water. The Springfield utilities department chose the James River. During the planning process it was recognized that the amount of water needed from the river had strong potential for significantly degrading aquatic habitat downstream of the point of proposed water withdrawal.

To quantify the potential impacts upon aquatic habitat due to withdrawing the needed water, the U.S. Fish and Wildlife Service and the Missouri Department of Conservation conducted an In-stream Flow Incremental Methodology analysis. In-stream flow requirements for three life stages of four species of fish were analyzed—smallmouth bass, black redhorse sucker, channel catfish, and the greenside darter. The study indicated that proposed water withdrawal amounts would reduce aquatic habitat by 34 to 50 percent during July through December in years that the James River re-

ceived normal amounts of stream flow. During times of drought, habitat would have been much worse. With the help of modelled scenarios of various potential hydrologic conditions in the James River basin, negotiations between the fish and wildlife agencies and water supply agencies resulted in a plan. The plan determined the allowable amounts of water which were to be withdrawn along a graduated scale that was consistent with decreases in stream flow resulting from periodic changes in hydrology (times of drought).

HYDROPOWER WATER USE OF MISSOURI

INTRODUCTION

Since the earliest days of settlement, the residents of Missouri have called upon the rivers and springs of the state to provide power. The unique physiography and hydrology of Missouri, especially in the Ozarks, is well suited to the development of local hydropower sources. Industry and society both profited from early efforts in hydropower development; not only was water power vital to manufacturing and commerce, the facilities which drew upon it also served as the nuclei around which many communities developed.

Early attempts to harness the force of running water fell into four broad categories: tub mills, undershot wheels, overshot-wheels, and turbines. Most common were the under- and overshot wheels. The overshot wheel relied upon water falling from a flume to turn it; the undershot wheel used the water flowing beneath it. Of the two, the overshot wheel used water more efficiently, because it relied upon the weight of falling water rather than the velocity of the flowing stream. But all of these paled in comparison to the turbine, which was invented in the 1830s. The turbine was more compact and durable than the older water wheels. More importantly, it operated on a vertical axis, whereas the under- and overshot wheels relied upon a horizontal axis. This simple adjustment allowed water to strike all of the blades (or buckets) at once, greatly improving efficiency. Every operating hydropower facility in the United States can trace its development to the success of these improvements. To this day they are the foundation upon which hydroelectric power generation is built.

While the devices are used only rarely, these methods are still applicable today. Most authorities agree that any further development of large-scale hydropower projects in the state is unlikely. This is not to say, however, that hydroelectric power generation will become any less important in the future. Anyone having a generator, a wheel and access to flowing water can self-supply part or all of their personal energy requirements. As Missouri moves into the twenty-first century, changes in the electric utility industry may lead to (or even necessitate) an increase in small-scale operations.

DEFINITION OF HYDROPOWER

Moving water used to generate electricity falls under the “hydropower water use” category. In categorizing water uses, the Department of Natural Resources does not distinguish hydropower water use from thermoelectric power water use. The Major Water Users Database gathers water use data for hydroelectric power and thermoelectric power production under the Electrical Generation category. The USGS, on the other hand, separates the two, recognizing thermoelectric water use as an “off-stream” use and hydropower as an “in-stream” use. Large hydropower projects (such as Bagnell Dam at Lake of the Ozarks, and Clarence Cannon Dam at Mark Twain Lake) typify hydropower water use, but other users (most notably, the Taum Sauk pumped-storage facility in Reynolds County) are includ-

ed as well. For the purposes of this report, "hydropower" is broadly defined as the use of water to generate electricity at facilities where the turbine generators are driven by moving water.

SOURCES OF WATER FOR HYDROPOWER

Unlike most other water uses, hydropower relies almost exclusively upon surface water sources. Several rivers and streams in Missouri (and their watersheds) provide water for hydropower generation. Not every river basin, however, can be used to generate hydropower. A watershed must meet exacting topographic and geologic standards before its hydropower potential may be exploited. Geologic formations at the proposed site must provide a stable platform for the planned facility, and have minimal seepage. At the same time, the river valley must not be overly wide, and must have sufficient relief to provide acceptable head. The economic and engineering considerations of meeting these strict criteria make hydropower development impractical in most river basins.

HYDROPOWER WATER USE

Types of Hydropower

One of the most productive ways we use water today is to generate electrical power. There are principally three ways water is used to produce hydroelectric power: standard hydropower dams, pumped storage facilities, and run-of-river power plants.

The most common way hydropower is generated today is through the use of hydropower dams. When the water stored behind the dam is released through turbines, electricity is generated.

Pumped storage facilities operate somewhat similarly in that water is impounded and released to generate electricity. However, instead of impounding free flowing water, as is the case with a typical dam, water is pumped upwards to an elevated reservoir during low power demand periods and then released back to its original source when it is needed.

A third type of hydropower facility, known as a "run-of-river" dam, does not impound water. It simply utilizes the water flowing in the river when generation is desired, and runs all or part of that water through the hydropower turbines.

Within Missouri there are eight hydropower dams currently producing power. These facilities include four privately owned and operated plants, and four operated by the U.S. Army Corps of Engineers (figure 29). With some variation, all of these hydropower facilities operate in much the same way.

Every hydropower facility produces electricity by using the force of moving water. The amount of power a hydropower facility can produce at any given time is determined by a combination of factors that include discharge, hydraulic head, and powerplant efficiency. This relationship can be expressed mathematically by the equation:

$$P=QH\gamma E$$

where P is power, Q is the discharge through the turbine, H is the net head (headwater elevation - tailwater elevation - losses), γ is the weight of water, and E is the efficiency of the turbine and the generator. Water is driven through the blades of the turbine, pushed by the weight of the water column behind the dam. For every foot of water depth, about 62.4 pounds per square foot is exerted.

In hydropower production, electricity is generated as water passes through the turbines. As water is driven through them, pressure is exerted upon the turbine blades, causing them to spin. The spinning turbine wheels produce electricity in the generator, which is then distributed to homes and businesses via the transmission network.

Pumped-storage hydropower facilities operate on the same principle, but use a markedly different technique. These plants use surplus power generated during off-peak periods to pump water from a lower reservoir to an upper one. The water pumped to the upper reservoir is then "stored" as potential energy until it is required during periods of peak power demand. When it is needed, it can be

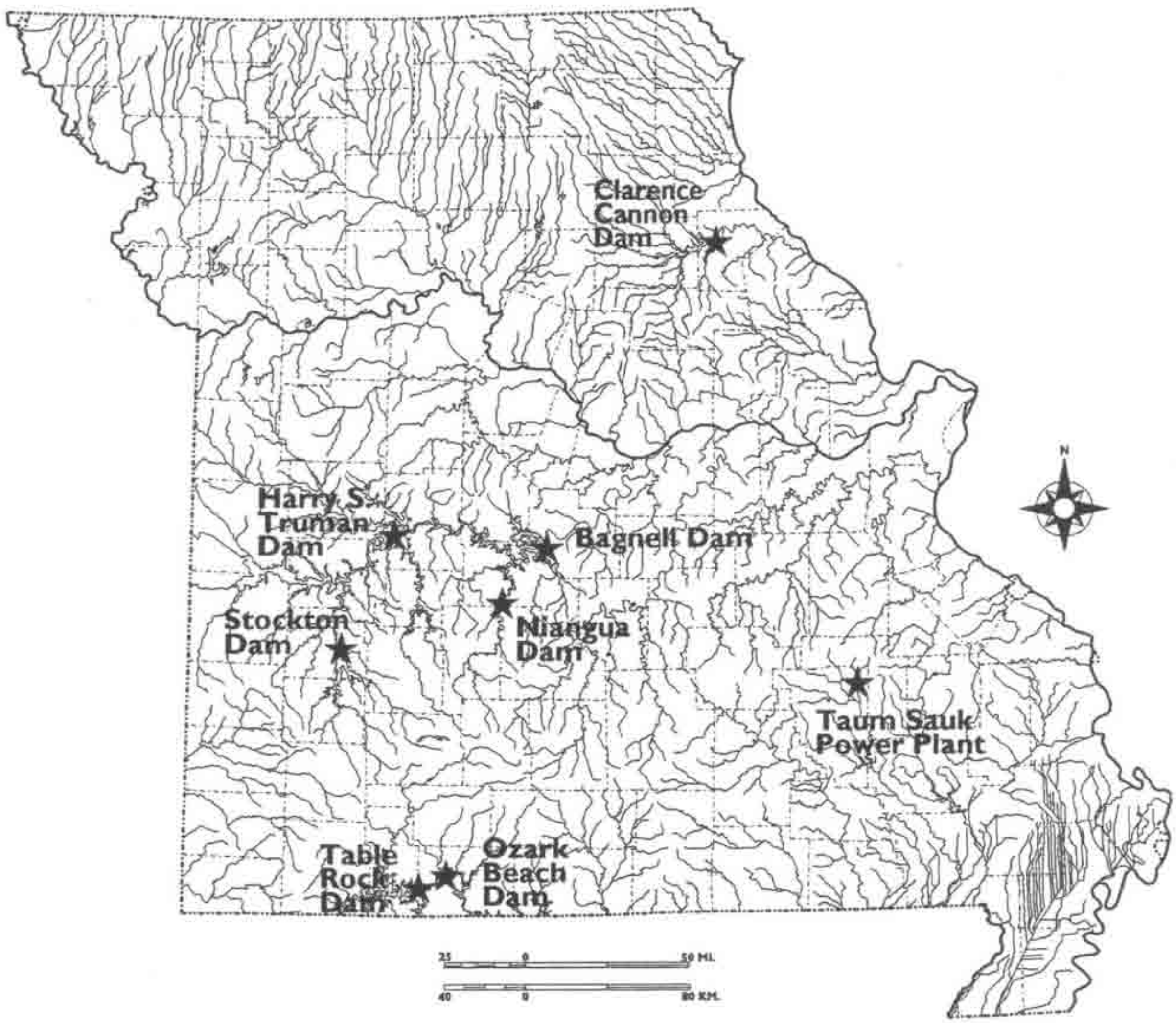


Figure 29. Hydropower facilities in Missouri

released back down to the lower reservoir, producing energy as it passes through the turbines of the facility. The differences in elevation between the upper and lower reservoirs of most pumped-storage operations are generally much greater than the maximum available hydraulic head found at most hydropower dams. As a result, pumped-storage plants can force water through their turbines at significantly higher pressures, and produce more power per unit volume of water than the typical hydropower dam. Smaller reservoirs and reduced equipment sizes translate into reductions in the real costs of power production. In addition to this, it allows the water used for production to be "recycled," since the water in the system simply moves back and forth between the upper and lower reservoirs.

Engineering constraints and environmental costs make construction of pumped-storage facilities difficult. Because of this, the only pumped-storage facility currently operating in Missouri is the Taum Sauk Plant owned and operated by Union Electric in Reynolds County. The Taum Sauk Plant is operated remotely from the Union Electric Osage Plant at Bagnell Dam, and serves exclusively as power production to meet electrical system emergencies and peak energy demand. The Harry S Truman and Clarence Cannon projects are also capable of pumpback operations; the Truman facility is not currently conducting them in the interest of fish and wildlife protection.

The third kind of hydropower facility, run-of-river, does not operate by impounding water. Instead, it relies upon the natural flow of the river to generate energy. Run-of-river operations typically divert either all or a portion of the flow of a stream through water wheels similar to those found in the "typical" hydropower dam. However, because of the smaller difference between the water surface and turbine elevations, these "low-head" dams generate a lower water pressure than "typical" dams and therefore require greater volumes of water per unit of power. Still, enough energy is expended by the river in turning the turbine wheel (or wheels) to generate electrical power. Alternately, the force of the turning wheel may be translated directly to mechanical output, as was the case for many of the early mill operations.

Usage Characteristics of Hydropower

Hydropower water use differs from other water uses reported in Missouri largely because of the unique way in which hydropower generation "uses" water. The cumulative water use of Missouri's hydropower facilities is so great that it far outweighs other uses in the state. Despite the vast amount of water required to generate power, however, hydropower generation is considered a non-consumptive use of water. For this reason, it is often left out of charts depicting overall water use in Missouri.

During the course of a day, the amount of water released through the turbines of a hydropower facility may change significantly. Hydropower facilities, because they are most often used to meet peak energy demands (see COMPARATIVE BENEFITS OF HYDROPOWER, page 62), release more water when demand is high than when it is low. When additional power is needed (usually in the late morning through early afternoon), releases can abruptly increase by thousands (or tens of thousands) of cubic feet per second. During off-peak periods, releases decline as energy requirements can be met efficiently without the use of hydropower.

Hydropower water use is also more subject to regional climatic influences than other uses. In periods of drought, in-flows to hydropower reservoirs can be substantially reduced. Although water storage in the reservoir may reduce the immediate impact of drought conditions, extended drought may make it necessary to curtail releases. Ultimately, less water is available for use in power production.

Similarly, flooding may force hydropower plants to release more water than desired through their turbines to compensate for increased in-flows; they may also need to release water through a spillway if flooding becomes severe. This water is, in effect, "wasted" because it cannot be put to productive use. This volume of the State Water Plan reports the 1993 water use figures for hydropower, which are

somewhat inflated over what might be anticipated in a more "normal" calendar year because of the record flooding that occurred during the spring and summer months of 1993.

Substantial investments in equipment and construction are also characteristic of hydropower water use. Only a small number of watersheds in Missouri have the potential to support the development of hydropower (see SOURCES OF WATER FOR HYDROPOWER, page 58). The costs of realizing this potential can be imposing because of substantial planning, engineering and construction costs, and the large tracts of land that must be purchased. As a result, only a limited number of sites in Missouri have developed hydropower potential; even fewer have undeveloped potential.

OVERVIEW OF HYDROPOWER WATER USE FOR INDIVIDUAL PROJECTS

Union Electric operates the Osage Power Plant at Bagnell Dam on the Lake of the Ozarks. Completed by 1931, the Osage Plant was constructed primarily to generate hydropower. In the intervening years, the Lake of the Ozarks has come to provide important recreational and fish and wildlife benefits as well.

From the Osage Plant, Union Electric also controls the Taum Sauk pumped-storage facility adjacent to Johnson Shut-Ins State Park in Reynolds County. The volume of water available for hydropower generation at the Lake of the Ozarks is approximately 919,000 acre-feet; an additional 4,460 acre-feet of water is available for use in the upper and lower reservoirs of the Taum Sauk facility. In 1993, the Osage Plant reported use of slightly more than 5,500 billion gallons of water to produce 1,330,826 megawatt/hours of power. During this period, Union Electric's Taum Sauk Plant generated more than 55,000 megawatt/hours of electricity with a reported water use of 913 million gallons.

The Sho-Me Power Corporation operates a run-of-river plant on the Niangua River, used to supplement system requirements of the Sho-Me Power Corporation not met by other plants. The Niangua Plant, also known as Tunnel Dam, employs a unique method of operation.

Between the dam site and the powerhouse, the Niangua River meanders around a bluff, dropping significantly in elevation by the time it reaches the other side. The Niangua Plant takes advantage of this by diverting a portion of the Niangua River's flow into a tunnel drilled through the bluff and down to the powerhouse built on the other side. After passing through the turbines, the water is returned to the Niangua River, "borrowed" briefly to produce electricity. In 1993, the Niangua Plant reported a water use of 58.9 billion gallons and an annual power production slightly greater than eight gigawatt/hours. Unlike many dams in the state, Tunnel Dam has no hydropower storage, being a run-of-river facility. As a result, actual output from year to year varies with the volume of inflows from the upper Niangua River watershed.

The Empire District Electric Company operates a run-of-river facility on the White River, known as the Ozark Beach Plant. As is the case with the Sho-Me Power Corporation's Niangua Plant, there is no hydropower pool for the facility to draw upon; the facility instead relies primarily upon releases from Table Rock Dam, 21 miles upstream. The Ozark Beach Plant also provides additional power to the Empire District Electric Company to meet its power needs; it generated 83,535 megawatt/hours in 1994. The Empire District Electric Company recently estimated the water use necessary to produce maximum output at 815 billion gallons, roughly half of the reported water use of the upstream Table Rock facility.

The United States Army Corps of Engineers owns and operates four hydropower facilities in Missouri: Stockton Dam at Stockton Lake on the Sac River, Harry S Truman Dam on the Osage River, Clarence Cannon Dam at Mark Twain Reservoir on the Salt River, and the Table Rock Dam at Table Rock Lake on the White River. Each of these projects are similar in that each has a large volume of storage allocated to multiple uses. The smallest, Clarence Cannon Dam, stores slightly less than 250,000 acre-feet of water in Mark Twain Lake. Projects developed by the Corps of Engineers, unlike many private projects, ad-

dress a wide range of uses, including hydropower, flood control, recreation, fish and wildlife programs, water supply and maintenance of navigation. Water use and power production for Corps of Engineers projects for 1993 are shown in table 9 below.

Unlike many privately owned and operated hydropower facilities, U.S. Army Corps of Engineers facilities do not market the power they generate. Instead, they rely upon intermediaries (such as the Southwestern Power Administration and Associated Electric Cooperative, Inc.) to distribute their output. Organizations such as these rely upon a network of generation facilities to provide power, and do not limit themselves to in-state sources. Because of this, any discussion of hydropower must recognize the contributions of facilities located in other states. For example, the Bull Shoals plant (located in northern Arkansas) provides a great deal of energy to Missourians. In the 1994 calendar year, the Bull Shoals plant used 1.86 trillion gallons of water to generate 101 gigawatt/hours of energy. Distribution of hydropower generation (and other sources, such as nuclear and fossil fuels) tends not to recognize state lines; ultimately, each thermoelectric power facility in Missouri is a component of a national (even international) power network.

CONSUMPTIVE USE VERSUS RETURN FLOW

Hydropower generation uses an extraordinary volume of water; nevertheless, we consider it a non-consumptive use of water. Before it is actually used though the amount of water available for hydropower generation is considerably reduced by evaporation losses. In 1990, evaporation losses for the eight hydropower facilities described above were estimated at slightly more than 260 billion gallons of water.

COMPARATIVE BENEFITS OF HYDROPOWER

The foremost use of hydropower in Missouri comes from its value as a generator of power during peak demand periods. Once engaged, coal-fired plants require an extensive amount of time to become operational. At this point, power can be generated across a range of capacities, but most efficiently at a specific level. Utilities prefer to operate at this level, but will operate above efficient capacity if necessary. Unfortunately (from an efficiency standpoint), demand for power is not constant; it varies with the time of day and season of the year (figures 30 and 31). Coal-fired power plants are typically built to meet minimum around-the-clock power demands, and are

TABLE 9
1993 Water Use and Power Production, US COE Facilities

Facility Name	1993 Water Use *	1993 Power Production
Stockton	129 billion gallons	135 gigawatt/hours
Harry S Truman	568.5 billion gallons	398 gigawatt/hours
Clarence Cannon	90 billion gallons	37 gigawatt/hours
Table Rock	1.7 trillion gallons	973 gigawatt/hours

* 1993 water use and power production figures inflated by record flooding during spring and summer months

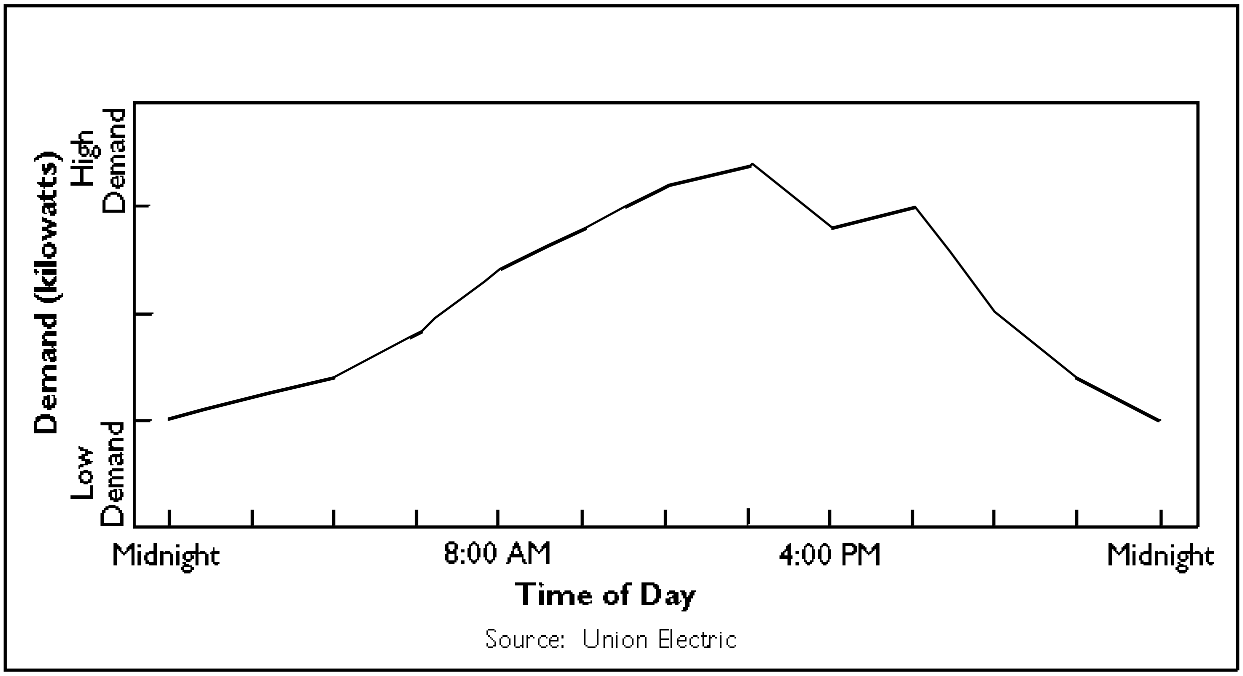


Figure 30. Daily demand curve for electricity

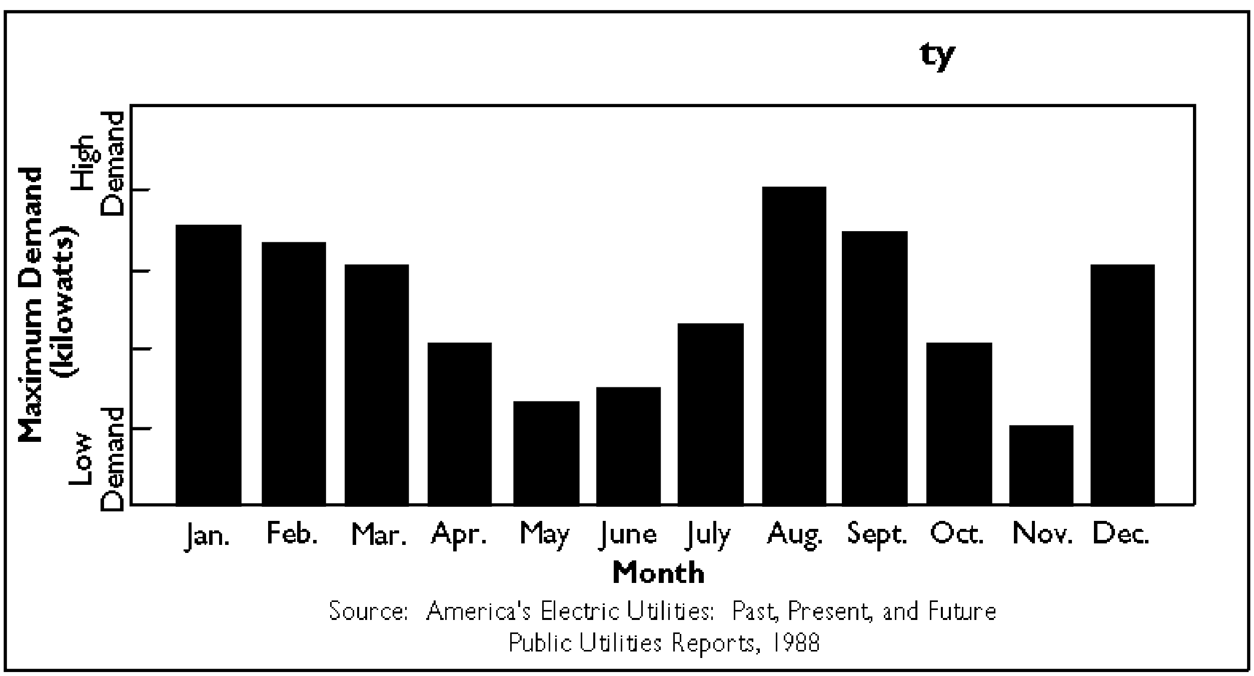


Figure 31. Monthly demand for electricity

sometimes referred to as baseload plants. During periods of peak demand (mid-afternoon and again in the early evening), the demand for electricity exceeds the supply that nuclear and coal-fired baseload plants can provide. Hydropower facilities have a number of attributes that make them ideal providers of electricity during these periods. Hydropower plants (unlike coal-fired plants), can provide power within minutes of activation and can frequently repeat the start/stop sequence. Furthermore, in comparison to baseload plants, they require very little start-up power to come on line. They are also highly flexible in terms of output. Because of the ease with which hydroelectric generators start and stop, it is a simple matter to meet variable peak demand by controlling the number of turbines in operation at any given time.

These characteristics also make hydropower plants important sources of emergency power. The efficiency, rapid start-up intervals and power requirements of hydropower facilities enable them to meet sudden additional energy demands. Were a generator in a baseload plant to fail or come off-line for maintenance, hydropower is easily and immediately accessible. In other words, hydropower provides system security for electric utilities, allowing better and more frequent maintenance of coal-fired plants as well as a quick remedy to large-scale black- or brown-outs.

Pumped-storage facilities have the added benefit of being able to “store” potential energy. As shown in a typical daily demand curve, the demand for electricity during late night and early morning hours is far below the supply provided by baseload coal-fired plants. As has been already noted, it is extremely impracticable to take these plants off-line because of the difficulties involved with stopping and restarting baseload, coal fired plants. On the other hand, there is currently no acceptable means by which to store surplus power supplies; power generated but not consumed immediately, if it cannot be resold, is lost. Pump-storage facilities provide a partial solution to this problem. Power supplies that might otherwise go unused are instead directed towards pump-storage facilities that use the electricity to pump water back to the upper reservoir. In this way, pump-storage facilities function as large “batteries” by storing potential energy during low demand periods in anticipation of the power generated by the release of water during peak demand periods. A portion of the power generated by baseload coal-fired plants during low demand periods is saved as a result in pump-storage facilities, and is available to meet peak demands during daylight hours.

Most hydropower facilities operating in Missouri offer significant alternative benefits to the public. Because of the environmental and social impacts of building dams, the Federal Energy Regulatory Commission (FERC) often requires the developer to mitigate the effects of construction and operation. This is usually done by enhancing other beneficial uses, such as recreation, fish stocking and flood control. For example, to mitigate the negative impacts of dam construction and operation on local fish populations, Union Electric (as part of the licensing of Bagnell Dam by FERC) agreed to develop and maintain a fish hatchery (Dan Jarvis, personal communication, 1995). Most facilities producing hydropower recognize the importance of multi-purpose operations. In fact, only two percent of dams nationwide declare hydropower generation as their primary purpose (figure 32). In Missouri, recreation is an important secondary beneficial use derived from many hydropower generating dams. One of Missouri’s most important recreational areas—Lake of the Ozarks, exists only through the impoundment of the Osage River. While Bagnell Dam was constructed principally for hydropower generation, the recreational opportunities provided by the dam have become famous throughout the Midwest. Although recreation represents the predominant additional public benefit derived from hydropower, other alternative benefits also exist. Some of these reservoirs provide a source of public water supply. All four of the dams operated by the U.S. Army Corps of Engineers keep a portion of reservoir capacity storage for flood control. In the long run, each of these uses—

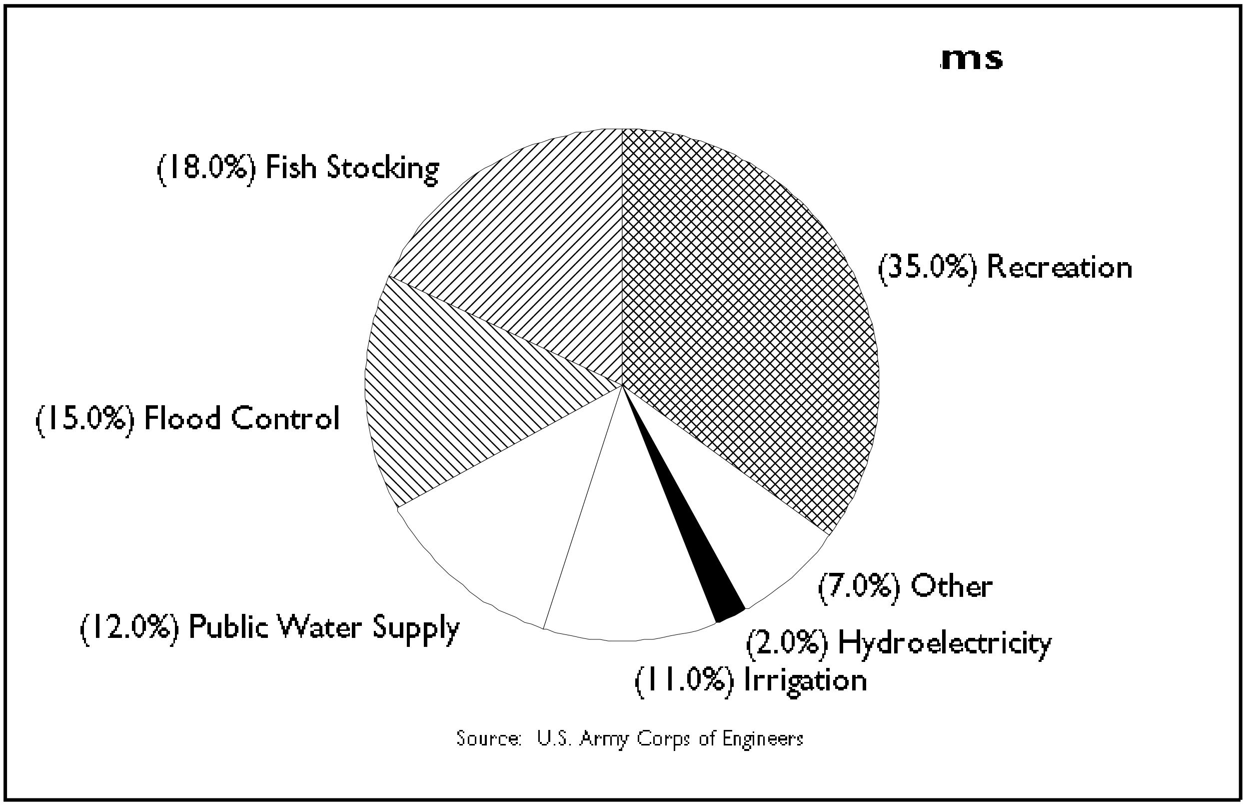


Figure 32. Primary purposes of U.S. dams

flood control, fish stocking, public water supply, and recreation—helps temper the social and environmental costs associated with hydropower development.

Hydropower represents a cleaner, less expensive source of energy than traditional coal-fired baseload plants. For example, every million megawatt/hours generated by Missouri's hydropower plants saves our economy (and environment) nearly 2.4 million barrels of oil. To provide perspective, consider that the four federal hydropower projects operating in Missouri alone generated 1,743 million megawatt/hours in 1993, which is equivalent to 4.15 billion barrels of oil. Hydropower is an efficient producer of electricity, providing power at efficiencies between 85 and 92 percent. Engineering and environmental constraints seriously limit the potential for future hydropower development. However, if existing hydropower sites were fully developed to their peak efficiencies, the resulting reductions in pollution from coal-fired plants would be substantial. Improvements in air quality would stem from reduced exhaust emissions, thermal water pollution would fall with declining water requirements for power plant cooling, and the threat of groundwater pollution from thermal waste products (primarily ash and scrubber sludge) would be reduced. Hydroelectric plants are also cheaper to operate. Every kilowatt-hour of electricity produced by hydropower plants costs approximately 25 percent of similar operating and maintenance costs faced by nuclear and coal plants. Further, because hydropower plants do not expend fuel to produce electricity, their operating costs are not subject to increasing fuel prices.

Lastly, hydropower plants were some of the earliest sources of power in many parts of the country. Because old hydropower facilities have very low plant and equipment costs (and nonexistent fuel costs), they provide inexpensive electricity to many rural areas nationwide.

WATERBORNE COMMODITY TRANSPORT WATER USE

INTRODUCTION

The transportation of commodities in river barges is a major use of the Missouri and Mississippi Rivers. This can be a fuel efficient, economical mode of commodity transport. One barge can carry as much as 58 over-the-road trucks or 15 jumbo-hopper rail cars. Figure 33 demonstrates the energy efficiency of using waterways versus railroads or trucks. The graph indicates the number of miles one ton of commodity is moved using one gallon of fuel. Barges are almost 10 times more fuel efficient than trucks and about 2.5 times as fuel efficient as moving commodities by rail. Lower transportation costs translate into more profit for products, such as farm products, and paying less for goods purchased. Because of competition between modes, waterborne commodity transport may provide significant price competition for shipping commodities.

TONNAGE SHIPPED

STATEWIDE

According to a 1995 study conducted by Mercer Management Consulting, in 1992 there were 29 million tons of commodities that either originated from, or were received by sources within the state of Missouri. A breakdown of Missouri's domestic waterborne commerce by commodity can be found in Table

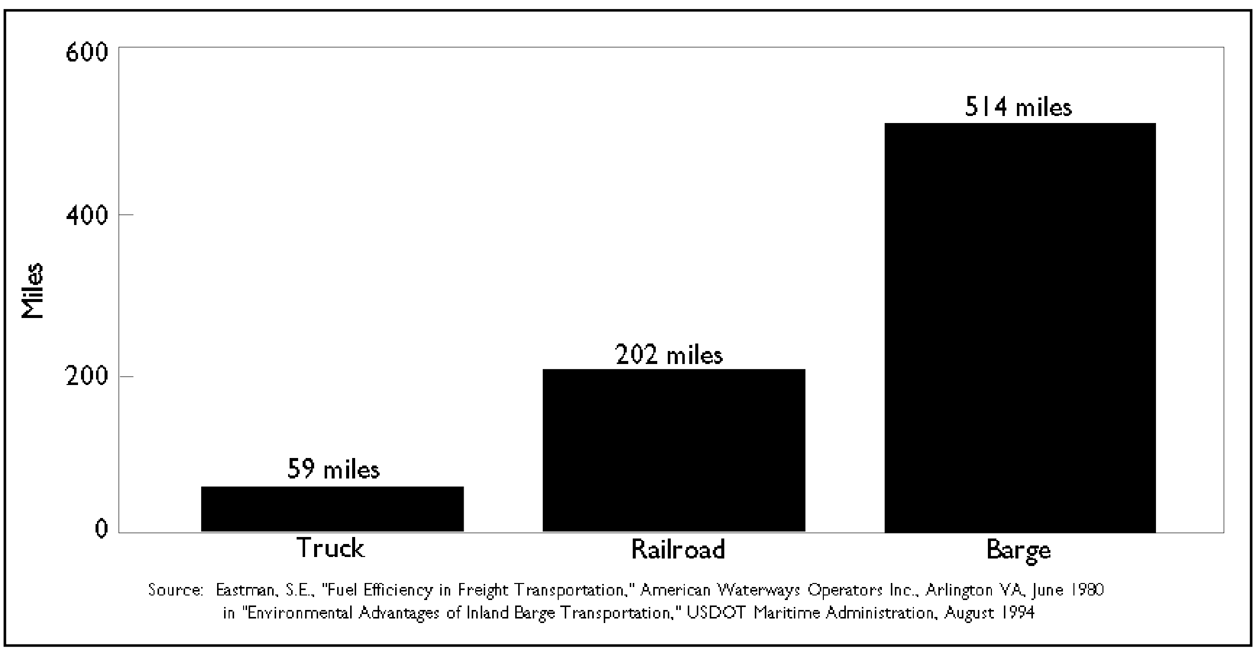


Figure 33. Energy efficiencies: truck, rail and barge. Number of miles one ton of commodity is moved using one gallon of fuel.

10. Coal makes up the bulk of commodities at 12.6 million tons, with the sand and gravel category amounting to 7.3 million tons. Fertilizers accounted for one million tons. Food and food products account for only 0.1 million tons.

TABLE 10
Missouri's Domestic Waterborne Commerce by Commodity
1992

Received and Originated	Volume (million tons)
Coal, lignite, and coke	12.6
Sand, gravel, shells, clay, and salt	7.3
Primary non-metal products	3.5
Petroleum products	1.3
Chemical fertilizers	1.0
Chemicals excluding fertilizers	0.6
Non-ferrous ores and scrap	0.6
Food and food products	0.1
Primary metal products	0.1
Withheld disclosure	1.8
Total	**28.9**

Source: Mercer Analysis of U.S. Army Corps of Engineers' State-to-State Public Domain Database, 1992.

MISSOURI RIVER

According to *Waterborne Commerce of the United States*, a publication by the U.S. Army Corps of Engineers, the total tonnage shipped on the entire length of the Missouri River in 1994 was about 8.5 million tons. This was up from the last several years, which ranged between five and six million tons. Those years included seasons with reduced draft (lighter loading) and reduced season length due to drought, and periods when the river was shut down because of flooding. Of the 8.5 million tons shipped on the Missouri River, sand and gravel led with 6.1 million tons; 1.1 million tons were fertilizers, food or farm products. Appendix 8 shows a breakdown of the different commodities shipped on the Missouri River in 1994 and the total volumes shipped 1985 to 1994.

MISSISSIPPI RIVER

The total commodities shipped on the entire length of the Mississippi River in 1994 was about 497 million tons, according to Waterborne Commerce of the United States. Appendix 9 has a detailed breakdown of the commodities shipped on the Mississippi River as reported in that study. The volume and diversity of commodities shipped on the Mississippi River were much greater than those shipped on the Missouri River. Sand and gravel accounted for about 9.8 million tons of the commodities shipped on the Mississippi River in 1994, fertilizers amounted to 17 million tons, and 146 million tons were food and farm products. Appendix 9 also presents total tonnage shipped on the Mississippi River for the years 1985 through 1994, which ranged from 384 million tons to 497 million tons.

USAGE CHARACTERISTICS

The Missouri River navigation system depends on a large system of reservoirs to supplement flow downstream of the reservoirs. For full service navigation, enough water is released to maintain a navigation channel 300 feet wide and nine feet deep. In times of water shortage, the U.S. Army Corps of Engineers reduces the amount of water released. A flow of approximately 41,000 cubic feet per second at Kansas City, provides full service navigation (9-foot draft). A flow of approximately 35,000 cubic feet per second at Kansas City provides minimum support to navigation (8-foot draft).

The length of a normal navigation season on the Missouri River is eight months, extending from April 1 to December 1. The season is halted for the winter months because of river freeze-up and ice (in the upper part of the basin). The season length can be shortened (or halted) when water is short, or lengthened when there is excess water in the reservoirs and when temperatures are high enough to avoid ice formation.

In contrast, the Mississippi River uses a series of locks and dams to maintain channel depths adequate for navigation. Locks move barges past the accompanying low level dams, operating as water-filled elevators. The lock and dam system maintains navigation on the upper Mississippi River, even during times of very low flow. Lock and Dam 27 is the southern most lock and dam and is located six miles downstream of the confluence with the Missouri River. The Mississippi River is a free flowing river system (no more locks or dams) from Lock and Dam 27 to its mouth. This means that water depths are no longer controlled by lock and dams and is dependent on adequate flow to maintain channel dimensions. On this lower portion of the Mississippi River system, navigation can be encumbered and traffic greatly reduced during dry periods. At stages below two feet (approximately 90,000 cfs) on the river gage at St. Louis, barge traffic on the Mississippi River is encumbered. At a stage of -4.5 feet (approximately 44,000 cfs) on the gage at St. Louis, all navigation halts (*Volume 6D: Economic Studies, Master Water Control Manual, Missouri River, Review and Update*, July 1994, U.S. Army Corps of Engineers).

Unlike the Missouri River System, the navigation season normally continues 12 months a year on the Mississippi River, although there can be some problems with ice.

High water can restrict movement of commodities on both the Missouri and Mississippi rivers. The U.S. Coast Guard monitors conditions for safety and sometimes closes the river during flood events. Consideration is given to both safety of the vessel as well as potential affects that the barge tows would have on the river system (i.e. wave impacts to levees).

WATER-BASED OUTDOOR RECREATION

Outdoor recreational use of Missouri's water resources is a significant portion of the total outdoor recreation activities that Missourians, as well as people visiting the state, participate in and cherish as a valued opportunity. Everyone from those having grown up in Missouri to those who have traveled through the state, and who have had an opportunity to stop by a swimming area at one of Missouri's many lakes or streams, carry with them fond memories of the state's lakes, rivers, springs, or wetlands. The popularity of our state's splendid water resources continues to grow. A common symbol of the state of Missouri is the use of our vast water resources be it a riverboat ride on the Missouri River or a canoe trip down the Current or Eleven Point rivers in the Ozark National Scenic Riverways.

The 1994 Census data was examined by the University Extension Office of Social and Economic Data Analysis for population growth of incorporated places since 1990. Out of the top ten incorporated places with a population of at least 2,500, the third, fourth, and tenth fastest growing places are near public recreational lakes. Hollister (third) and Branson (fourth) are near Table Rock Lake in southwest Missouri. Camdenton (tenth) is near Lake of the Ozarks. Camdenton was observed to be growing three times faster than in the 1980s.

In some areas of the state, high quality water flowing in rivers and through lakes is the catalyst for a tourism industry centered around recreation in those waterbodies. Entire communities have sprung up as a result of the water-based recreational opportunities created by the existence of large reservoirs. River recreation is also a popular activity, in southern Missouri, spurring a tourism industry in the vicinity of the river reaches receiving the recreational activity.

Recreational water uses can be created by other uses. For example, a reservoir built for hydropower can become a host of reservoir-related recreation. However, recreation is not always compatible with other uses. A lake that has a hydropower generation facility at the dam, and recreational facilities on the lake, sometimes experiences limited use of the water resource for one of the uses due to overriding demand for that water by the other use. For example, the hydroelectric facility might need to generate quantities of power within a limited time period that would cause the water surface elevation of the lake to decrease several feet over a period of a few weeks. Recreational users might consider a decrease of that amount in lake elevation to be detrimental to their activities. On a lake that considers recreation the top priority use, the hydropower facility would not be able to meet the demand for electricity.

Conflicting uses of the water can also occur with riverine recreation. For example, a relatively small stream has a potential of being rendered unavailable for recreational use due to a water diversion or a withdrawal structure being built that removes a significant portion of the stream flow. Significant demand upon the stream for recreational use might dictate not withdrawing water, curtailing, or eliminating that use.

In situations where uses of a water resource conflict with one another, it is often beneficial to determine the water needed for each type of use, evaluate those needs, and to develop an arrangement that would allow for at least limited availability of the water for the various uses. The supply of water may not be as much as is desired, however there may be an opportunity to supply the amount of water actually needed.

RECREATIONAL WATER USERS DEMAND

Water-based Outdoor Recreation Activities

The *Missouri Statewide Comprehensive Outdoor Recreation Plan 1991-1996 (SCORP)* includes user information pertaining to outdoor recreational activities that are dependent on the presence of water. These activities are referred to as water-based activities. The SCORP conducted user surveys among outdoor recreationists in Missouri and identified 43 outdoor recreation activities. The 43 activities were ranked by the number of users engaging in each activity. Seven of those 43 activities are water-based. The survey estimates the amount of use each activity receives in units of activity-days, i.e., an individuals participation in an outdoor recreation activity in any portion of a day. Table 11 presents the water-based activities, ranking of each activity among the 43 activities, total activity days for 1989, and projected total activity days for 1995. Swimming receives the most use with an estimated 1989 total of 57.2 million activity-days and ranks third in total use among all outdoor activities.

Adult and Child Participation

Table 12 compares adults to children 1989 total activity-days spent per capita for each water-based activity. Swimming receives the most activity days from both adults and children, 9.7 and 15.4 activity-days per capita respectively. Fishing receives almost as many activity-days from adults as swimming with 8.9 activity-days per capita. Children spend much fewer activity-days per capita (4.8) fishing than they do swimming (15.4).

Table 11

Water-based Outdoor Recreation Activities

Activity	Rank	Million Activity Days	
		1989	**1995 (projected)**
Swimming	3	57.2	59
Fishing	5	40.3	45
Motor Boating	13	21.0	26
Water Skiing	26	6.6	8.2
Canoeing	31	4.1	4.2
Non-motor/ Row Boating	33	2.6	2.7
Sailing	36	1.8	1.9
Total		133.6	147.0

Table 13 presents the percent of the adult population of Missourians participating in each water-based recreational activity during 1989. Swimming and fishing both receive participation from more than 50 percent of adult Missourians.

The high popularity of lake recreation continues. With the exception of Lake of the Ozarks, the largest impoundments are managed by the U.S. Army Corps of Engineers.

Tallies are kept by the Corps of the annual total number of user hours spent on most of the reservoirs the agency manages in Missouri. Figure 34 summarizes this information for recent years. Annual total visitor hours for 1988, 1990, 1992, and 1994 are presented for reservoirs that reported annual user hours. Table Rock reservoir in Barry, Stone, and Taney counties receives the most visitor hours, averaging greater than 30 million visitor hours per year during the four years presented.

Smaller impoundments also receive significant numbers of visitors. A survey con-

TABLE 12

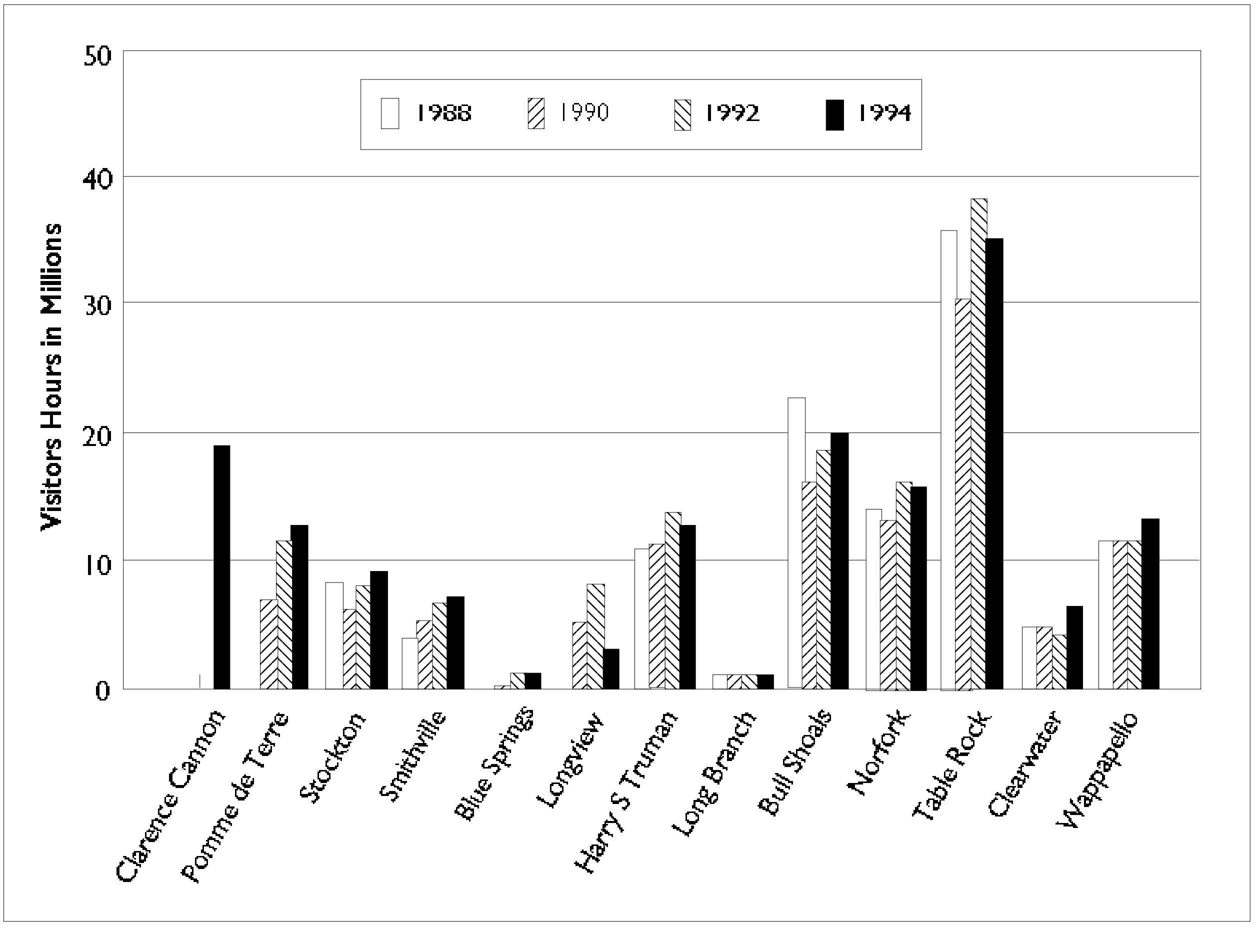
Per Capita and Statewide Adults & Children Outdoor Recreation Demand in Activity-Days, 1989

Activity	Adults		Children	
	Per Capita	**Statewide (millions)**	**Per Capita**	**Statewide (millions)**
Swimming	9.7	37.2	15.4	20.0
Fishing	8.9	34.1	4.8	6.2
Motor Boating	4.5	17.1	3.0	3.9
Water Skiing	1.3	5.1	1.1	1.5
Canoeing	0.9	3.4	0.6	0.7
Non-motor/Row Boating	0.6	2.2	0.3	0.4
Sailing	0.4	1.6	0.2	0.2
Total		100.7		32.9

TABLE 13

Adult Participation Rates for Water-based Outdoor Recreation Activities, 1989

Activity	Participation Rate (%)
Swimming	52.1
Fishing	52.2
Motor Boating	34.1
Water Skiing	16.1
Canoeing	21.3
Non-motor/Row Boating	11.9
Sailing	4.8



NOTE: Clarence Cannon, Pomme de Terre, Blue Springs, and Longview sometimes lacked data compatible with that presented here as indicated by missing bars in this illustration.

Figure 34. U.S. Army Corps of Engineers reservoirs in Missouri, recreational visitor-hours

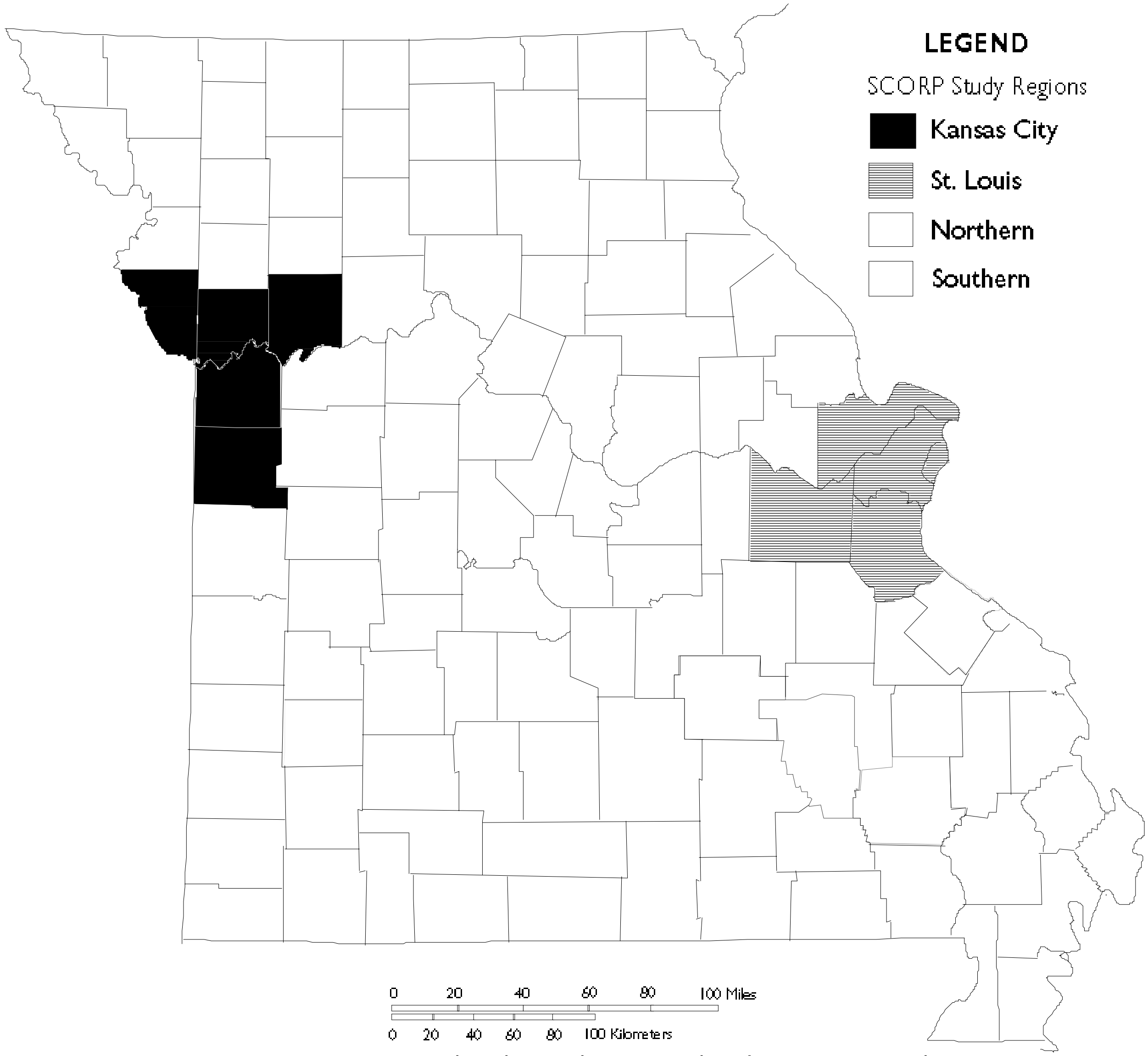
ducted from 1983 to 1988 by the Missouri Department of Conservation estimated 14 percent of all fishing in Missouri occurred at ponds smaller than five acres.

RECREATIONAL WATER RESOURCES

Public Lakes and Streams

The Missouri Statewide Comprehensive Outdoor Recreation Plan 1991-1996 (SCORP) estimated the total acreage of public lakes and miles of public streams available for public outdoor recreational use. The total acres of public lakes within the state is reported as 269,017. The total miles of public streams within the state is reported as 17,736.

The data is reliable at a resolution of four regions within the state; two urban regions—St. Louis, Kansas City—and two rural regions—northern Missouri, and southern Missouri. Figure 35 presents the boundaries of the four regions, total acreage of lakes within each region, total miles of public streams within each region, and acres or miles per 1,000 residents within each region. Table 14 pre-



Source: 1990 State Comprehensive Outdoor Recreation Plan, Inventory Regions

Kansas City Region-
17,163 acres of lakes
(18.94 acres per 1,000 people)
551 miles of streams
(0.61 miles per 1,000 people)

St. Louis Region-
6,704 acres of lakes
(3.67 acres per 1,000 people)
861 miles of streams
(0.47 miles per 1,000 people)

Southern Region-
208,592 acres of lakes
(150.07 acres per 1,000 people)
9,310 miles of streams
(6.7 miles per 1,000 epople)

Northern Region-
36,558 acres of lakes
(40.35 acres per 1,000 people)
7,014 miles of streams
(7.74 miles per 1,000 people)

Figure 35. Public use lakes and streams, acreages and miles

sents these same numbers by region and statewide.

Southern Missouri has more than three times as many acres of public lakes (208,592) than the other three regions combined (60,425). This can be accounted for by the fact that southern Missouri has topographic and hydrologic characteristics more conducive to the development of large multi-purpose reservoirs than does northern Missouri. The two rural regions have the demographic advantage of much more undeveloped, unpopulated space available for developing such large reservoirs.

TABLE 14

Public Lake Acreage for Outdoor Recreation Use:

Region	**Acreage**	**Per 1,000 Population**
St. Louis	6,704	3.67
Kansas City	17,163	18.94
Northern Missouri	36,558	40.35
Southern Missouri	208,592	150.07
Total/(Average)`	269,017	(53.48)

Public Stream Miles for Outdoor Recreation Use:

Region	**Miles**	**Per 1,000 Population**
St. Louis	861	0.47
Kansas City	551	0.61
Northern Missouri	7,014	7.74
Southern Missouri	9,310	6.70
Total/(Average)	17,736	(3.53)

Private Ponds

In 1977 the Missouri Department of Conservation estimated that, as of 1975, there were 315,000 private impoundments in Missouri smaller than 1,000 acres with a surface area totalling approximately 195,000 acres. Distributed throughout the state, it was estimated the greatest concentrations are in northern and west-central Missouri where rolling terrain and clay soils have provided more suitable conditions for pond construction. Ponds per square mile are estimated to be 5.7 in northern and west-central Missouri, 2.1 in Southeast Missouri, and 4.1 in the remainder of the state. Results from a 1990 survey by the Missouri Department of Conservation indicate there may be many more ponds than previously estimated. The 1990 survey estimated more than 827,000 ponds in Missouri totalling more than 820,000 acres. The differences in the 1977 survey and the 1990 survey may be an indication that it is uncertain as to approximately how many ponds are in Missouri.

Springs

Springs are a significant recreational resource in Missouri. Trout rearing for the purpose of recreational fishing is thought to be the most common recreational use of Missouri springs today. The lower average water temperature of spring flow creates an aquatic environment unusual in the midwest by making it possible to maintain cold-water fisheries in the receiving waters of those springs. Some of the larger springs in Missouri are also popular to visit for simply experiencing the micro-environment created by unusually cool, high quality water, at its point of discharge. The Department of Natural Resources, Division of Geology and Land Survey has more than 2,800 springs on record for Missouri. Many springs are not recorded. Most are located in the Ozark Region due to the karst topography which creates avenues for ground water to enter surface water as a point source.

For a look at specific springs and their characteristics including hydrologic, physical, cultural, faunal, and floral descriptions, see *Springs of Missouri*, DNR, 1982.

QUANTITY OF WATER USED

The largest recreational use of water is lake recreation. From a quantitative standpoint, the most significant water need for lake recreation is that of maintaining appropriate water surface elevations of the lake. Most recreational lake users would prefer a constant lake elevation throughout the recreational season and for as long as possible. Water access facility owners and operators can construct and manage facilities less expensively and provide more convenient services to recreationists if the water surface elevation and location of water edge can be relied upon to be constant. Most recreational lakes in Missouri have multiple uses which prevents maintaining a constant water surface elevation. In such cases a determination of the true water needs would be beneficial to know. This might provide a basis for developing a compromise with other water use needs for the resource.

Maintaining a constant reservoir level can have an effect on the water that is available for other uses in a reservoir or downstream of it. By conducting water balance calculations (storage = inflow + outflow - losses), we can determine the volume of water that is “lost” to other uses attributed to maintaining a constant pool elevation. This would consider variables such as the amount of water lost downstream during dry periods to keep the reservoir full and excess water discharged during wet periods.

The amount of water needed to maintain a constant water surface elevation is equivalent to the amount of water exiting the reservoir, i.e., losses, discharges and withdrawals. Losses would include seepage and evaporation from the reservoir. Discharges would be the amount of water allowed to exit the reservoir and continue flowing down the watercourse. Withdrawals would be the amount of water taken out of the reservoir and conveyed to off-stream uses. Recreational uses of a reservoir would prefer to be assured that a quantity of water equivalent to the exiting water volume would simultaneously enter the reservoir. This might be considered the preferred amount of available water. Realistically, a recreationist could only

hope for maintaining water surface elevations within a range of a few feet, making it at least feasible to provide access facilities and services at the shoreline.

Quantifying water used for river recreation is a type of in-stream flow calculation. A predominant criteria from a quantity perspective is maintaining adequate water depth in the channel. Boats, for example, require various minimum water depths depending on the design of the boat. In Section 5 of this report, titled “In-Stream Water Flow and Its Uses,” Table 6 presents typical required water depths for various types of recreational watercraft. River hydraulics calculations are conducted to determine the amount of water required to be flowing in the river channel to maintain the desired water depth.

FISH AND WILDLIFE

Fish and wildlife water use is one of the most complex water uses of the state's waters. In addition to the environmental need for water to use for fish and wildlife, fishing is important to Missourians. As presented in the recreation section of this publication, fishing is enjoyed by more than 50 percent of Missourians. It is a billion dollar industry in the state.

Because of abundant surface water in Missouri, it is generally assumed that there are ample volumes of water available to meet the drinking water needs of terrestrial wildlife during most years, although accessibility may sometimes be a problem. Beyond this basic need of water for drinking, water is directly used by aquatic wildlife to maintain the habitat on which they depend.

Aquatic animals require a water environment in which to live, be it a lake, river, or wetland. Each aquatic species has a range of aquatic habitats within which it can survive. Within that habitat is a narrower range of habitat within which it will not only survive but flourish. Fisheries biologists have made information available that describes the habitat needed by individual species. Important parameters of fish habitat affected by in-stream flows include water depth, water velocity, watercourse substrates, and cover. Changes in any of these parameters causes changes in habitat and possibly the elimination of some species.

The hydrologic component for defining aquatic habitat is primarily the flow regime. Variations in timing of flows can adversely impact aquatic life. The minimum flow adequate for fish varys depending upon the species and season of the year. In riverine environments channel maintanence flows (see In-stream Flow section) are important for defining the characteristics of pools and riffles in a watercourse and removing finer substrate materials. Some species do not tolerate excessive accumulations of silt or require it be periodically removed from the stream bottom and local habitat.

Appendix 5 characterizes flow regimes in terms of long term mean discharge for the 12 calendar months at 280 stream gages around the state. The In-stream Flow Section also describes methods being used to calculate the hydrologic requirements for sustaining aquatic habitat for specific stream reaches. Many additional hydrologic statistical parameters can be used to more accurately characterize flow regimes.

AQUATIC COMMUNITY CLASSIFICATION SYSTEM

The *Aquatic Community Classification System For Missouri* (Pflieger 1989) is based primarily on patterns of fish species distribution and relative abundance because there is more of this information available for fish than other aquatic organisms. This classification is geographically divided into four principal faunal regions and 16 divisions (figure 36). The Ozark, Lowland, and Prairie regions correspond to major physiographic subdivisions. The fourth principal region identifies Missouri's two largest watercourses, the Missouri and Mississippi rivers. Subdivisions of the Ozark, Prairie, and Big River Regions are determined based upon major drainage areas. Distribution patterns within the Lowlands Region do

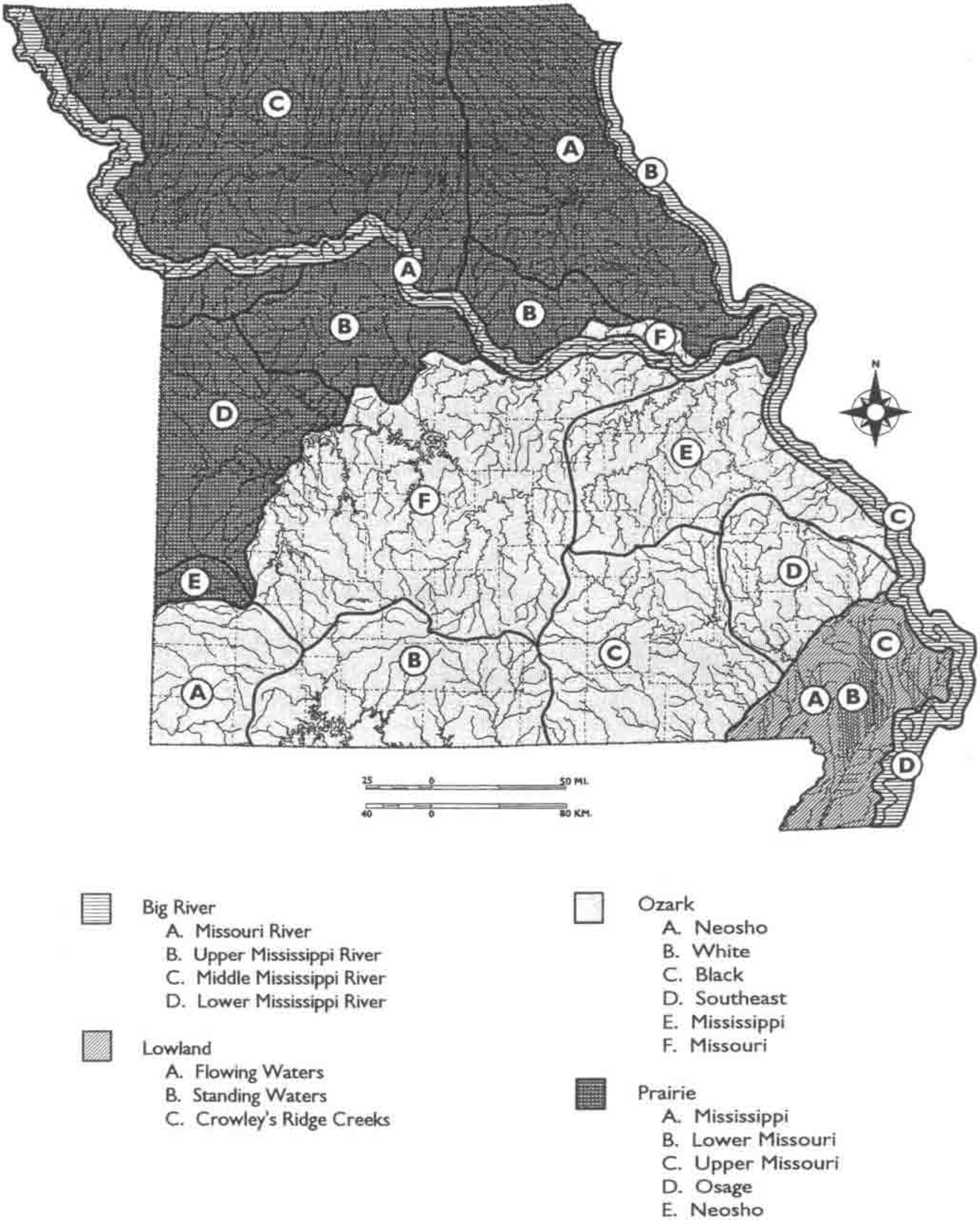


Figure 36. Aquatic faunal regions of Missouri and their divisions

not correlate well with drainage relationships (Pflieger, 1989). Subdivisions in the Lowlands Region are not defined.

Regional Hydrologic Regimes

The Aquatic Community Classification System For Missouri briefly describes hydrologic regimes for the four faunal regions. Stream flow within the Big River faunal region is described as continuous strong flow with one or more periods of sustained flooding each year. The Missouri River division of the Big River region is described as historically having wide fluctuation in volume of flow. Construction of six main-stream reservoirs upstream of the state of Missouri have modified the natural flow regime. An extensive system of rock dikes and revetments has increased velocities in the main channel and reduced backwater areas. The Lower Mississippi River division of the Big River faunal region is described as having volume of flow more than double that of the Middle Mississippi River division (due to contributions from the Ohio River).

Stream flow within the Lowland faunal region is described as having well-sustained base flows due to the alluvial deposit aquifers of the Missouri "Bootheel." The "flowing waters" division generally has permenant flow with the larger rivers and drainage ditches having considerable current, while some of the smaller watercourses are without noticeable current. Water bodies in the "standing water" division typically have drastically fluctuating water levels on a seasonal basis. Current only occurs during floods.

Streamflow Classified by Stream Size

Flow of the streams in the Ozark and Prairie faunal regions is described in terms of distance from the headwaters of the watercourse being described and stream order (Strahler method). This perspective is the criteria for the geographic distinction between fish community zones described in these two regions. The units of measure are miles-to-headwater and stream order positive integers. Both increase with a downstream progression. Using 7.5 or 15 minute topographic maps, the upstream beginning of a watercourse is identified as the headwater of a stream. At the headwater, a watercourse is zero miles-to-headwater and has a stream order of one. Moving downstream, the miles-to-headwater is equal to the length of the watercourse from the point of interest to the headwater. Progressing downstream from the headwater, the stream order would increase one integer with each confluence between two watercourses with equal orders, i.e., when two watercourses intersect, each having a stream order of one, the resulting downstream watercourse stream order would be two. When that watercourse confluences with another watercourse of stream order two, the resulting downstream watercourse stream order would be three.

Based upon the number of miles-to-headwater and stream order, four zones are recognized in the Aquatic Community Classification System For Missouri. The headwater zones include watercourses with miles-to-headwater of zero to six and stream orders I, II, and III. Creek zones include watercourses with miles-to-headwater from seven to 31 and stream order V or less as well as miles-to-headwater less than seven with stream order IV or V. Small river zones include watercourses with miles-to-headwater from 32 to 96 and stream order VI or less, as well as miles-to-headwater less than 31 with stream order VI. Large river zones includes watercourses with miles-to-headwater 97 or greater, as well as all reaches with stream order VII or VIII.

The Ozark Faunal Region Headwater Zone stream flow is described as usually reduced to a series of isolated pools in late summer on many Ozark headwaters while others may be entirely dry for long stretches. Springs and spring seeps are sometimes numerous but usually small. Ozark Faunal Region Creek Zone stream flow is frequently zero in late summer, but permanent pools are maintained by seepage through the bars that separate them. Ozark Faunal Region Small River Zone stream flow has large springs present along

many streams of this Zone, and these have a marked effect on the flow characteristics. Small rivers generally have permanent flow across their riffles, even in the most severe droughts.

The Prairie Faunal Region Headwater Zone stream flow is described as subject to wide fluctuations in flow. By late summer, flow has usually ceased. Larger pools generally contain water except in the severest droughts. Prairie Faunal Region Creek Zone stream flow is low or non-existent during dry periods of late summer, but the pools are generally permanent. Prairie Faunal Region Small River Zone stream flow generally maintains some flow except in the most severe droughts. Prairie Faunal Region Large River Zone stream flow is permanent.

Special Communities

Hydrologic regimes of “special communities” in the Ozark and Prairie faunal regions, including spring branches, overflow waters, and sinkhole ponds, are also briefly described in the Aquatic Communities Classification System for Missouri. In the Ozark Region, spring branches are subject to wide fluctuations of flow, but generally having better-sustained flows than surface streams that are not spring-fed. Overflow waters (abandoned stream channels) have no current except when adjacent streams are flooding. Sinkhole ponds usually do not intersect the water table, are relatively shallow, and are subject to marked seasonal fluctuations in depth.

For the Prairie Faunal Region, spring branch descriptions are provided for freshwater as well as mineral spring branches. Freshwater springs are small and may cease to flow in late summer. Most are directly connected to sinkholes and other sources of surface water, and are subject to rapid and wide fluctuations in flow. Mineral springs generally have a small but permanent flow. Overflow waters have current absent except during floods. Sinkhole ponds are relatively shallow and are subject to drastic seasonal fluctuations in depth, or dry completely in late summer.

A summary of other regional physical characteristics as well as characteristic fauna of the Aquatic Communities Classification System for Missouri is presented in Appendix 10.

For a look at specific watersheds, the Missouri Department of Conservation has completed river basin fisheries management plans for several watersheds in Missouri and hope to complete plans for all Missouri watersheds by the year 2000. Aquatic habitats and aquatic fauna within the subject watershed are evaluated. Channel characteristics and hydrology of the major watercourses pertinent to habitat concerns in the watershed are described.

ENDANGERED AQUATIC SPECIES

Endangered species are an immediate concern in ecosystems experiencing loss of critical habitat for endangered species. Lack of attention to those areas in the near future could cause extinction or extirpation (eradication) of those species known to be endangered. A first step toward protecting critical habitat is to be aware of the species in an area that are threatened, endangered, or no longer existing there. Species with such status can be indicators that the water-bodies within which those species have become endangered are being adversely impacted. Aquatic endangered or extirpated species in Missouri are listed in Appendix 11 and highlighted in the Aquatic Communities Classification System summarized in Appendix 10.

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APPENDICES

APPENDIX 1:

ESTIMATING PERSONAL, HOUSEHOLD AND MUNICIPAL WATER USE

ESTIMATING PERSONAL WATER USE

Although estimating personal water use is difficult to do precisely, one can estimate the amount of water he or she uses on any given day. When it comes to using water, most of us are fairly predictable. We shower, we do laundry, we cook our meals, all of which use quantifiable amounts of water. Keeping an eye on how we use water (and how much of it each use requires) allows us to estimate how much water we use. It also allows conservation-minded individuals to look for ways to conserve water.

Most estimates of personal water consumption utilize use one of two approaches. The first method approximates personal water use by summing the amounts of water used in everyday activities. Although the actual numbers provided may vary according to personal habits and plumbing fixtures, Table 1 below can be used to evaluate individual water use.

The quantities of water needed for many personal water use activities vary little from person to person. This makes it possible to estimate the amount of water the "average" person uses. However, this method cannot account for all personal water uses daily. The amount of water needed for some uses, like watering lawns and washing cars, can differ greatly from person to person. As a result, this approach tends to slightly underestimate personal water use. On the other hand, it "personalizes" water use very well, and allows individuals to see for themselves how effective water conservation measures can be.

Table 1

Average Personal Water Use Activities

Use	Gallons	Gallons per day	Percent Daily
Toilet (per flush)	1.5 - 5	25	37
Faucets (per minute use)	3	15	21
Bath/Shower (per minute use)	5	15	22
Daily laundry (per load)	25	10	15
Cooking/Drinking	3	3	5

Table taken from USEPA Manual of Small Public Water Supply Systems, 1991

The second method takes a more mathematical approach towards evaluating personal water use. Personal water use can be calculated by simply dividing the total distribution of a water supply by the number of users. For example, consider a hypothetical water supply which provides 84 million gallons yearly to 2,500 people. By dividing the 84 million gallons of water by 365 days, and again by the population of 2,500, we can estimate personal water use from this supply at approximately 92 gallons per person per day. Unlike the previous approach, this method accounts for all "personal" water uses. However, it also includes transmission losses and public uses (such as firefighting and park maintenance). It also fails to exclude commercial and industrial users who are tied in to the water supply. In contrast to the first method, this approach tends to overstate personal water use.

Because it is difficult to do with any precision, estimates of personal water use vary widely (Table 2). Since the two approaches discussed previously tend to either over or underestimate personal water use, it is logical to conclude that the amount of water used in "real" personal use lies somewhere in between. Given the nature of its approach, the first method cannot include some kinds of personal water use. Likewise, the second method includes some "uses" of water which cannot be truly ascribed to personal use. The "compromise" estimate of personal water use found in most references today lies somewhere between 90 and 100 gallons per person per day.

ESTIMATING HOUSEHOLD WATER USE

Household water use, in some instances, is easier to evaluate. The simplest approach involves the use of water meters. Many water utilities use water meters to measure the amount of water used by a household during a given period. By simply subtracting the meter reading at the beginning of the period from the reading at the end, the household can find out how much water it uses. While this approach does not provide much information about how water is used, it does give a very accurate estimation of how much water is

TABLE 2
Personal Water Use Estimates in Missouri

Data Source	Water Use (gallons/person/day)
U.S. Geological Survey, 1990 (Public Supply)	166
U.S. Geological Survey, 1990 (Self-supplied Domestic)	60
MDNR, Public Drinking Water Program (approximate)	239
MDNR, Division of Geology and Land Survey (1978) *	158
U.S. Environmental Protection Agency (nationwide estimate)	176

* Barbara Harris, Water in Missouri (Department of Natural Resources, Division of Geology and Land Survey, 1979)

used. It also allows the effectiveness of water conservation measures to be closely monitored.

Although less accurate, household water use can also be estimated mathematically. By dividing the total distribution of the local supply by the number of service connections (rather than population served), household water use can be roughly estimated. Water utilities usually keep record of the number of service connections to the water supply, as well as the number of people served. In many cases, the number of service connections to a water supply roughly equates to the number of households served. Consider the hypothetical public water supply example used to demonstrate a mathematical estimation of personal water use. By dividing the 84 million gallons of water supplied yearly by 365 days, and again by 900 service connections (rather than by 2,500 people) we can estimate that the "average" household uses 255 gallons of water every day. Table 3 below uses this approach to estimate household water use for selected municipal water supplies across the state. As with calculations of personal water use done by this method, this approach also includes transmission losses, public uses, and commercial/industrial users. For these reasons, this approach may overstate household water use.

Table 3
Estimated Household Water Use in Selected Municipalities

Municipality	Water Use (gpd)
Sparta	252
Hartville	354
Charleston	637
Cole Camp	190
Linn Creek	360
Poplar Bluff	284
Mountain Grove	161
Weaubleau	203
Windsor	292
Branson	554
Knob Noster	213
Osceola	250
Hannibal	388
Sarcoxie	250

Municipality	Water Use (gpd)
Pevely	468
Foristell	200
Liberty	454
New Franklin	214
Union Star	161
Lamar	265
Braymer	143
Savannah	220
Plattsburg	186
Goodman	222
Ellsinore	153
Fayette	404
Atlanta	108
Laredo	130
Hunnewell	86

Many homes do not receive water from public water utilities, and do not measure water use by metering. Adding up the personal water use of all family members does not accurately depict household water use because some activities (like cooking and laundry) are often done collectively. In addition, water-using activities like car washing and lawn watering should be considered "household" water use, and must be factored into the total household use. The amounts of water used in these activities can be especially difficult to measure. As a consequence, estimating household water use can become difficult. In these circumstances, the amount of water the "typical" household uses can be estimated through research. For example, researchers at the U.S. Environmental Protection Agency estimate that the "average" American family of four uses 300 gallons of water per day. This value is fairly consistent with the estimated average water use of 269 gallons per household per day taken from the above sample of municipalities.

ESTIMATING MUNICIPAL WATER USE

Municipal water use estimates, as might be expected, are much more complex than estimates of personal or household water use. They typically involve extensive research into residential (household) water use patterns and calculations of industrial and commercial water use. In the past, estimations of municipal water use commonly used a "per capita" approach, in which the daily quantity of water used by the "average" person was simply multiplied by the municipal population. Today, this method is widely considered inadequate, because it is based solely upon service area population. In an effort to improve accuracy, most current methods weigh the impacts of many variables housing types, household income, water prices, weather and seasonality, and local industrial/commercial patterns, to name just a few.

Evaluations of household water use are fundamental to municipal water use estimations. Because residential water use is central to estimations of municipal water use, accuracy is important. The 1990 U.S. Census reports 25,841 households in the city of Columbia. If we assume that each household uses 270 gallons of water per day, we can further estimate that 1990 residential water use in Columbia was approximately 2.55 billion gallons. In this case, a miscalculated "average" household water use value would be multiplied by 25,841 homes, creating substantial error. Most current municipal water use estimates attempt to reduce error of this kind by disaggregating (differentiated within their categories, or examined in a more detailed fashion) residential water users. Rather than assuming that all 25,841 households use the same amount of water every day, we instead assume that different kinds of households use different amounts of water. We can assume that single-family residences use a different amount of water than multi-family ones, that high income households use a different amount of water than low income ones, and that high density residential areas use different amounts of water than low density areas. A disaggregated approach allows us to depict residential water use more accurately. It can also allow us to forecast the effect changing socio-economic conditions might have on local water use.

Municipal water use estimates also attempt to characterize commercial and industrial water use patterns. Industrial water users use water in many ways because most have fairly specific needs. For instance, one user may need large volumes of untreated water, while another may require smaller amounts of especially pure water. Therefore, like residential water use estimates, industrial/commercial water use estimates are most accurate if they are disaggregated (high quality water from which steam is generated in thermoelectric power production). This is typically done through the use of Standard Industrial Classification (SIC) codes, which group together industries having similar economic characteristics. The SIC codes are useful because they are very specific; for example, bookstores use the SIC code 5942, and steel mills have an SIC code of 3312. A 1986 publication of the U.S. Bureau of the Census titled *Water Use in*

Manufacturing provides insight into the nature of water use for a number of industries nationwide. Prepared from a special survey of respondents reporting an annual intake of more than 20 million gallons of water during the *1982 Census of Manufacturing*, this report permitted the disaggregation (differentiation) of industries using significant amounts of water. In other words, it enabled researchers to establish rates of water use for very specific industries. Different industries use different amounts of water. Based upon SIC codes, water use researchers calculate "per employee" industrial water use rates, and apply them to municipal commercial and industrial establishments. This per employee approach allows one to calculate total water use for an industry by its size (number of employees). Bookstores use almost 20 gallons per employee per day; steel mills, on the other hand, use approximately 537 gallons every day per employee. Manufacturers of household appliances use slightly less than 172 gallons of water per employee per day. Water users in the printing and publishing industry use only 37.9 gallons of water per employee per day. By taking the number employed in each industrial and commercial category, and multiplying them by the category's estimated water use, we can estimate industrial and commercial water use. This information can be very useful for developing conservation programs or evaluating distribution systems. If total water use is desired, the disaggregated categories can be summed.

Total municipal water use can be estimated by adding residential, commercial and industrial water use together, and accounting for transmission losses and public uses. Although requiring some effort to establish, transmission losses can be reasonably estimated by most public water suppliers. By the same token, most suppliers will also have some record of "public" uses (such as fire department and park maintenance requirements).

APPENDIX 2:

MISSOURI MAJOR WATER USERS DATABASE SUMMARY

A law passed in 1983 by the Missouri General Assembly requires annual registration of the Missouri's major water users. A "major water user" is defined as any person, firm, corporation or governmental body or agency having a water source and a pump capable of producing 100,000 gallons of water or more daily. Because there are no penalties for non-registration, compliance with the law is essentially voluntary and registration is incomplete. As a result, the data presented in this Appendix does not represent all major water users in Missouri; neither does it depict total water use in Missouri. However, the Major Water Users Database is useful as a rough indicator of water use patterns in Missouri. Most of the maps depicting actual water use in Missouri are constructed from this data, as are many of the accompanying tables and charts. The Major Water Users Database is the original data source for most of Missouri's water use information, and serves as the basis for this report.

Each year, major water users are sent inventory forms which request information on withdrawal quantities and locations. Appendix 2 does not list individual reporting major water users; instead, it summarizes reported major water user withdrawals. For every county in Missouri, the number of gallons of water reported withdrawn is shown in each category in the 1993 calendar year.

The Major Water Users Database is based upon eight pre-defined categories of use: domestic, municipal, irrigation, recreation, industrial, electrical generation, fish and wildlife, and drainage and dewatering. Water use categories currently employed by the Department of Natural Resources are defined as follows:

Domestic water use: Water used for household purposes and subsistence, livestock watering, and irrigation of gardens and orchards less than 2.5 acres in size.

Municipal water use: Water taken from public supplies for public consumption, such as community water systems and public water supply districts).

Irrigation water use: Water needed to supplement plant growth on lands greater than or equal to 2.5 acres in size.

Recreational water use: Water used for recreational purposes, such as swimming and fishing. Water used for aesthetic purposes is also included under the recreational water use category.

Industrial water use: Water used to produce marketable products in the course of economic activity. Industrial water use covers a broad range of activities, such as mining, manufacturing and commercial poultry/livestock feedlot operations. Industrial water use also includes uses (such as waste disposal and hydrocarbon displacement) in which water is injected back into the ground.

Electrical Generation water use: Water used in producing electrical energy by hydropower dams, thermal or nuclear power generation, or pumped-storage operations.

Fish and Wildlife water use: Uses which require water for the maintenance of fish and wildlife habitat, as well as subsistence of fish and wildlife populations. Water used for aquaculture is also registered under this category.

Drainage, Dewatering and Effluent Discharge water use: Evacuation of water from mines and quarries, drainage of agricultural areas, and waste disposal.

Major Water Users Registration Summary Table-
Organized by county
NOTE: Water use totals shown in gallons per year

County	Domestic	Municipal	Irrigation	Recreation	Industrial	Electrical Generation	Fish and Wildlife	Drainage and Dewatering	Total Water Use
Adair	0	907,970,000	10,000,000	0	0	0	0	0	917,970,000
Andrew	5,600,150	179,786,400	16,000,000	0	0	0	0	0	201,386,550
Atchison	0	59,763,000	88,000,000	0	0	0	0	0	147,763,000
Audrain	54,000	663,498,000	1,418,108,900	9,840,000	89,766,000	0	9,843,000	0	2,191,109,900
Barry	245,316,834	330,334,580	0	0	777,252,280	0	4,380,000,000	10,610,250	5,743,513,944
Barton	298,896,600	233,179,300	534,562,000	0	0	0	0	0	1,066,637,900
Bates	10,412,700	477,423,982	0	0	0	0	0	0	487,836,682
Benton	4,234,000	175,845,090	9,320,000	8,998,300	0	568,504,400,000	0	0	568,702,797,390
Bollinger	0	76,388,500	851,040,000	0	0	0	0	0	927,428,500
Boone	228,135,973	5,188,593,836	83,200,450	0	23,950,840	170,317,000	0	0	5,694,198,099
Buchanan	0	6,094,841,028	0	0	0	14,788,420,000	0	0	20,883,261,028
Butler	76,909,300	1,173,255,753	53,866,332,479	0	0	0	158,133,000	0	55,274,630,532
Caldwell	0	114,986,100	0	0	0	0	0	0	114,986,100
Callaway	233,104,700	314,671,923	312,677,000	0	0	7,802,460,000	0	0	8,662,913,623
Camden	177,852,400	190,461,000	116,000,000	0	0	58,867,000,000	0	0	59,351,313,400
Cape Girardeau	17,950,000	2,463,670,740	403,541,160	50,000	86,232,330	376,200	0	0	2,971,820,430
Carroll	0	405,435,200	0	785,600	0	0	0	0	406,220,800
Carter	0	38,471,900	0	0	0	0	0	0	38,471,900
Cass	0	630,023,218	96,470,000	0	0	0	0	0	726,493,218
Cedar	72,679,159	183,190,991	4,200,000	2,926,009	68,253,600	128,994,600,000	0	0	129,325,849,759
Chariton	68,574,600	92,482,100	114,300,000	5,800,000	736,000	0	0	114,390,000	396,282,700
Christian	251,854,250	284,796,794	20,000,000	1,022,300	121,235,676	0	0	59,943,800	738,852,820
Clark	43,057,700	172,001,400	75,432,000	0	14,700,500	0	0	0	305,191,600
Clay	235,000,000	47,111,257,536	0	1,000,000	133,776,935	0	0	13,779,352	47,494,813,823
Clinton	0	431,645,433	0	1,650,000	73,009,288	0	0	6,030,069	512,334,790
Cole	1,141,399,947	970,841,300	0	0	66,540,000	0	0	0	2,178,781,247
Cooper	0	553,319,300	0	0	0	0	0	0	553,319,300
Crawford	0	348,318,471	0	0	0	0	108,000,000	0	456,318,471
Dade	300,000	122,727,400	819,281,496	688,000	0	0	0	0	942,996,896
Dallas	0	0	0	0	0	0	0	0	0
Daviess	0	80,428,800	0	0	0	0	0	0	80,428,800
DeKalb	0	39,394,000	0	0	0	0	0	0	39,394,000
Dent	0	0	43,824,000	0	0	0	9,406,780,000	0	9,450,604,000
Douglas	0	0	124,750,000	0	0	0	0	0	124,750,000
Dunklin	0	1,250,376,400	5,005,043,344	0	0	0	10,868,000	0	6,266,287,744
Franklin	2,850,000	1,857,292,870	0	150,000	51,060,940	349,602,756,000	0	0	351,514,109,810
Gasconade	0	324,860,600	15,168,000	0	0	0	0	0	340,028,600
Gentry	0	253,995,640	0	400,000	0	0	0	0	254,395,640
Greene	179,634,260	9,750,262,093	34,815,700	0	633,937,900	0	0	0	10,598,649,953
Grundy	0	750,000,000	318,968,000	0	0	0	0	0	1,068,968,000
Harrison	0	160,221,584	9,000,000	200,000	0	0	3,000,000	0	172,421,584
Henry	0	535,272,000	174,066,000	1,309,200	0	129,538,500,000	118,012,000	0	130,367,159,200
Hickory	8,541,495	29,661,390	0	2,333,900	0	0	0	0	40,536,785
Holt	102,996,780	60,434,467	20,800,000	0	0	0	70,470,000	4,708,564	259,409,811

Major Water Users Registration Summary Table-
Organized by county
NOTE: Water use totals shown in gallons per year

County	Domestic	Municipal	Irrigation	Recreation	Industrial	Electrical Generation	Fish and Wildlife	Drainage and Dewatering	Total Water Use
Howard	37,751,360	294,993,626	0	371,550	0	0	0	0	333,116,536
Howell	108,260,120	902,367,200	0	400,000	10,326,680	0	0	0	1,021,354,000
Iron	11,921,640	147,676,898	0	0	1,499,438,880	0	0	2,739,400,000	4,398,437,418
Jackson	4,172,012,000	3,947,533,000	0	0	2,660,778,000	145,876,420,000	0	3,000,000,000	159,656,743,000
Jasper	2,842,164,250	835,172,435	921,974,293	200,000	2,820,337,802	612,500,000	0	2,000,000	8,034,348,780
Jefferson	185,570,600	2,093,610,910	0	0	1,170,260,700	283,150,000,000	0	0	286,599,442,210
Johnson	307,911,264	965,806,700	93,803,000	0	3,861,000	0	0	0	1,371,381,964
Knox	4,120,560	49,837,800	0	0	125,300	0	0	1,481,540	55,565,200
Laclede	0	871,335,030	0	0	96,800,654	0	7,300,000,000	0	8,268,135,684
Lafayette	289,538,264	543,079,360	36,825,000	0	44,156,285	0	0	0	913,598,909
Lawrence	133,297,600	631,811,200	139,100,000	21,023,618	75,853,200	0	0	0	1,001,085,618
Lewis	0	202,769,300	0	0	0	0	0	0	202,769,300
Lincoln	0	491,258,100	12,800,000	0	0	0	0	0	504,058,100
Linn	186,359,000	167,995,100	16,900,000	0	56,112,900	0	0	0	427,367,000
Livingston	19,078,300	610,306,370	0	0	0	25,376,800	1,175,040,000	0	1,829,801,470
McDonald	65,083,400	561,272,300	60,000,000	0	190,000,000	0	0	0	876,355,700
Macon	452,289,305	39,744,300	0	264,700	121,030,495	293,400	0	0	613,622,200
Maries	1,641,600	27,300,400	0	704,000,000	3,690,400	0	0	0	736,632,400
Marion	533,517,700	416,067,746	203,752,000	0	1,043,288,500	0	0	0	2,196,625,946
Mercer	0	68,615,000	0	0	0	0	0	0	68,615,000
Miller	625,000	267,928,270	0	0	0	5,541,200,755,000	56,600,000	0	5,541,525,908,270
Mississippi	183,300	592,785,545	6,210,756,399	515,833	0	0	0	0	6,804,241,077
Moniteau	70,383,514	10,489,300	0	935,180	19,761,071	0	0	0	101,569,065
Monroe	0	836,737,000	0	0	0	0	0	0	836,737,000
Montgomery	0	76,086,680	0	0	0	0	0	0	76,086,680
Morgan	72,452,300	28,320,900	0	0	22,894,800	0	0	0	123,668,000
New Madrid	95,750,000	171,642,031	30,460,686,444	0	251,368,155	280,255,335,000	0	0	311,234,781,630
Newton	23,998,000	334,182,600	10,762,780	2,500,000	107,224,500	0	0	0	478,667,880
Nodaway	0	482,862,286	6,000,000	0	0	0	0	0	488,862,286
Oregon	43,509,024	531,541,089	0	604,292	8,460,088	0	0	0	584,114,493
Osage	0	171,313,500	0	0	0	11,849,560,490	0	0	12,020,873,990
Ozark	0	1,339,732,958	60,480,000	10,000	0	0	0	0	1,400,222,958
Pemiscot	1,000,000	712,148,041	5,148,477,246	0	60,000,000	0	436,000,000	0	6,357,625,287
Perry	175,000	527,532,060	0	0	2,375,670	0	0	0	530,082,730
Pettis	0	85,233,390	0	0	66,800,000	0	0	0	152,033,390
Phelps	53,773,520	901,955,400	0	2,020,000	0	0	2,595,938,000	0	3,553,686,920
Pike	155,432,000	280,682,000	54,600,000	0	1,979,972,000	463,562,000	0	175,200,000	3,109,448,000
Platte	0	755,221,400	0	14,240,000	7,424,000	130,993,177,700	0	0	131,770,063,100
Polk	0	433,149,854	40,099,456	25,000	0	0	0	0	473,274,310
Pulaski	1,379,683,000	621,784,614	5,000,000	5,326,000	60,000,000	0	0	0	2,071,793,614
Putnam	0	129,818,000	0	0	0	0	0	0	129,818,000
Ralls	0	0	35,218,000	0	94,000,000	0	0	0	129,218,000
Randolph	0	493,411,900	0	0	0	239,670,480,000	0	0	240,163,891,900
Ray	0	737,889,500	0	0	0	0	0	0	737,889,500

Major Water Users Registration Summary Table-
Organized by county
NOTE: Water use totals shown in gallons per year

County	Domestic	Municipal	Irrigation	Recreation	Industrial	Electrical Generation	Fish and Wildlife	Drainage and Dewatering	Total Water Use
Reynolds	102,936,750	7,202,260	0	500,000	7,000,000	913,230,000	0	7,113,600,000	8,144,469,010
Ripley	0	119,700,000	6,460,033,766	0	0	0	0	0	6,579,733,766
St. Charles	0	5,656,141,853	188,112,000	0	422,397,950	181,084,410,000	0	0	187,351,061,803
St. Clair	0	71,652,200	0	188,000	0	0	0	0	71,840,200
Ste. Genevieve	130,359,454	166,337,375	0	966,290	109,159,281	0	0	0	406,822,400
St. Francois	48,898,100	673,096,553	0	0	649,840,000	0	0	13,801,500	1,385,636,153
St. Louis	0	54,067,104,568	0	0	4,181,148,000	110,579,000,000	0	0	168,827,252,568
Saline	0	1,277,098,900	0	0	0	0	0	0	1,277,098,900
Schuyler	14,631,053	49,605,757	0	0	2,322,389	0	0	2,786,868	69,346,067
Scotland	0	122,381,853	7,335,000	0	0	0	0	0	129,716,853
Scott	2,642,384	1,415,782,200	4,799,597,803	1,000,000	9,085,500	309,052,800	1,000,000	0	6,538,160,687
Shannon	0	111,510,879	0	0	0	0	0	0	111,510,879
Shelby	0	87,735,900	0	0	0	0	0	0	87,735,900
Stoddard	338,132,750	365,303,200	27,560,272,302	1,000,000	414,347,000	0	0	0	28,679,055,252
Stone	41,590,000	287,693,700	2,620,800	0	0	0	0	0	331,904,500
Sullivan	0	283,457,000	0	0	0	0	0	0	283,457,000
Taney	235,702,792	2,515,063,255	15,000,000	0	3,200,000	0	6,125,615,000	0	8,894,581,047
Texas	36,000	434,524,498	214,834,000	0	206,829,750	0	0	0	856,224,248
Vernon	1,130,000	796,558,701	162,140,000	0	0	0	3,150,000	0	962,978,701
Warren	0	282,599,000	5,819,500	0	147,854,300	0	0	0	436,272,800
Washington	17,520,000	220,143,900	0	0	2,422,054,000	0	0	176,310,000	2,836,027,900
Wayne	365,000	193,091,520	0	0	8,745,400	0	1,490,000,000	0	1,692,201,920
Webster	0	330,169,799	259,584,000	0	0	0	0	0	589,753,799
Worth	0	10,447,140	0	214,000	0	0	0	0	10,661,140
Wright	0	328,899,700	0	800,000	11,042,000	0	0	0	340,741,700
St. Louis City	791,685	53,947,000,000	0	0	278,616,030	0	0	0	54,226,407,715

APPENDIX 3

USGS NATIONAL WATER-USE INFORMATION PROGRAM SUMMARY

Since 1950, the U.S. Geological Survey (USGS) has collected and compiled water use data for the entire United States. Prior to 1979, water use information compilations were largely unfunded efforts of variable accuracy. In 1979, the National Water-Use Information Program was established to "provide more uniform, current and reliable information on water use." Every five years, the USGS publishes water use estimates for the United States. The most current circular is titled *Estimated Use of Water in the United States in 1990*.

Most of the water use data compiled through the National Water-Use Information Program originates with state agencies. In Missouri, the original data source for most water use information is the Major Water Users Database maintained by the Department of Natural Resources. The USGS adjusts this data to conform to the National Water-Use Information Program categories. Where data is unavailable for a specific category, the USGS estimates water use information through pre-established techniques. For example, the Missouri Major Water Users Database does not collect livestock water use data. To remain consistent with data collection efforts in other states, the USGS estimates livestock water use in Missouri using a method similar to the one described in this report.

Water use information for all categories shown in the 1990 USGS circular is summarized by state and by two-digit hydrologic unit. However, the basic geographic units of the water use data collected by the USGS are counties and eight-digit hydrologic units. For each state, counties are aggregated to estimate statewide water use in each county. Similarly, water use estimates for each eight-digit hydrologic unit are aggregated into two-, four-, and six-digit hydrologic unit summaries. Although the Major Water Users Database serves as the basis for this report, USGS estimates of statewide water use for selected categories are also provided. In Appendix 3, USGS water use data estimates for eight-digit hydrologic units are shown (see also Appendix 4). Table 1 shows this information sorted by hydrologic unit number; Table 2 shows it sorted by hydrologic unit name.

As is the Missouri Major Water Users Database, the USGS National Water-Use Information Program is based upon several pre-defined categories of use. Appendices 3, Table 1 and Table 2 tabulate water use in nine categories:

Public water supply: Includes water withdrawn by public and private water suppliers, who provide water for various uses (such as domestic, commercial and industrial). To be included under this definition, suppliers must provide water to at least 25 persons, or have at least 15 hookups.

Commercial water use: Water used by commercial facilities such as hotels, restaurants, office buildings, government and military facilities, and retail sales stores. Commercial water use may be either self-supplied or delivered by public water suppliers.

Domestic water use: Includes water used for household purposes such as drinking, cooking, bathing, clothes washing, and watering lawns. Domestic water use may be either self-supplied or delivered from public supplies.

Industrial water use: Water used for industrial purposes such as fabrication, processing, washing and cooling, and includes such industries as steel, chemical and allied products, paper and allied products, mining and petroleum refining. As with commercial and domestic use categories, industrial water use may be self-supplied or taken from public water supplies.

Thermoelectric water use: Water use associated with thermoelectric energy production. Thermoelectric water use is divided into two sub-categories: fossil fuel power production water use and nuclear power production water use. The fossil fuel power production sub-category includes water used in the production of electric power generated through the consumption of coal, oil and natural gas. The nuclear power production sub-category includes water used in the production of electrical power generated by nuclear fission. Water use in the thermoelectric water use category may be either self-supplied or publicly supplied.

Mining water use: Includes water withdrawn for the extraction of minerals: solids (such as coal and ores), liquids (such as crude petroleum), and natural gases. While this category includes quarrying, dewatering and other activities associated with mining, it does not include the processing of raw materials.

Livestock water use: Water associated with the production of red meat, poultry, eggs, milk and wool. Not included are rural subsistence water use, irrigation water use, or other on-farm water uses. A sub-category of livestock water use, animal specialties, includes water use associated with the production of fur-bearing animals, horses, and aquaculture.

Irrigation water use: Water artificially applied on lands to assist in the growth of crops or pasture, or to maintain vegetative growth in recreational lands such as parks and golf courses.

Hydroelectric water use: Water used in power plants in which turbine generators are driven by the force of falling water.

TABLE 1

1990 USGS National Water-Use Information Program Summary Table-
Organized by hydrologic unit number
NOTE: Water use totals shown in gallons per year

Hydrologic Unit	Hydrologic Unit Name	Total Population	Public Supply	Commercial	Domestic	Industrial	Thermoelectric Power	Mining	Livestock	Irrigation	Hydroelectric Power	Total Water Use
07100009	Des Moines River	580	18,250,000	3,650,000	7,300,000	0	0	0	76,650,000	10,950,000	0	116,800,000
07110001	Fox/Wyaconda Rivers	13,540	284,700,000	36,500,000	102,200,000	18,250,000	0	0	208,050,000	73,000,000	0	722,700,000
07110002	North Fabius River	9,080	313,900,000	25,550,000	80,300,000	69,350,000	0	0	270,100,000	18,250,000	0	777,450,000
07110003	South Fabius River	8,600	485,450,000	14,600,000	3,650,000	361,350,000	0	0	219,000,000	69,350,000	0	1,153,400,000
07110004	North River and Main Stem (Salt River to Missouri River)	51,950	1,025,650,000	76,650,000	240,900,000	1,197,200,000	0	0	390,550,000	164,250,000	0	3,095,200,000
07110005	Salt River (North Fork)	28,110	667,950,000	18,250,000	116,800,000	0	0	0	350,400,000	102,200,000	0	1,255,600,000
07110006	Salt River (South Fork)	48,940	1,533,000,000	69,350,000	186,150,000	153,300,000	0	0	405,150,000	1,368,750,000	0	3,715,700,000
07110007	Salt River	11,550	441,650,000	36,500,000	65,700,000	463,550,000	0	0	266,450,000	397,850,000	257,419,900,000	1,671,700,000
07110008	Cuivre River	42,850	1,518,400,000	229,950,000	518,300,000	427,050,000	0	0	405,150,000	733,650,000	0	3,832,500,000
07110009	Dardenne/Peruque Creeks	157,110	3,759,500,000	401,500,000	489,100,000	219,000,000	154,880,450,000	0	18,250,000	146,000,000	0	159,913,800,000
07140101	Upper Mississippi River (St. Louis to Ste. Genevieve)	1,000,160	69,076,250,000	226,300,000	686,200,000	3,806,950,000	391,393,150,000	7,300,000	102,200,000	47,450,000	0	465,345,800,000
07140102	Meramec River	305,100	18,290,150,000	328,500,000	719,050,000	4,025,950,000	0	638,750,000	328,500,000	47,450,000	0	24,378,350,000
07140103	Bourbeuse River	48,960	1,095,000,000	149,650,000	474,500,000	25,550,000	0	0	215,350,000	14,600,000	0	1,974,650,000
07140104	Big River	77,080	1,773,900,000	233,600,000	693,500,000	3,387,200,000	0	379,600,000	131,400,000	29,200,000	0	6,628,400,000
07140105	Upper Mississippi River (Ste. Genevieve to Ohio River)	64,460	1,664,400,000	98,550,000	310,250,000	32,850,000	0	0	321,200,000	657,000,000	0	3,084,250,000
07140107	Headwater Diversion	35,300	1,660,750,000	135,050,000	430,700,000	40,150,000	0	0	284,700,000	1,292,100,000	0	3,843,450,000
08010100	Lower Mississippi River (Main Stem)	3,630	343,100,000	7,300,000	14,600,000	51,100,000	0	0	0	2,102,400,000	0	2,518,500,000
08020201	New Madrid Floodway	35,780	1,478,250,000	58,400,000	715,400,000	62,050,000	386,049,550,000	0	47,450,000	5,748,750,000	0	394,159,850,000
08020202	Upper St. Francis River	42,590	974,550,000	138,700,000	434,350,000	835,850,000	0	1,434,450,000	193,450,000	740,950,000	0	4,752,300,000
08020203	Lower St. Francis River	18,510	908,850,000	40,150,000	109,500,000	156,950,000	0	0	29,200,000	17,151,350,000	0	18,396,000,000
08020204	Little River	97,790	3,905,500,000	135,050,000	357,700,000	485,450,000	1,485,550,000	0	135,050,000	37,032,900,000	0	43,537,200,000
08020302	Cache River	680	40,150,000	3,650,000	10,950,000	0	0	0	3,650,000	1,989,250,000	0	2,047,650,000
10240001	Missouri River (Iowa to Nishnabotna River)	0	7,300,000	0	0	0	0	0	3,650,000	80,300,000	0	91,250,000
10240004	Missouri River (Nishnabotna River)	480	32,850,000	0	3,650,000	7,300,000	0	0	10,950,000	262,800,000	0	317,550,000
10240005	Missouri River (Holt and Atchison Counties)	11,960	306,600,000	25,550,000	80,300,000	58,400,000	0	0	175,200,000	2,299,500,000	0	2,945,550,000
10240010	Nodaway River	5,320	386,900,000	29,200,000	91,250,000	3,650,000	0	0	222,650,000	135,050,000	0	868,700,000
10240011	Missouri River (Andrew, Buchanan and Platte Counties)	114,160	4,263,200,000	120,450,000	368,650,000	390,550,000	138,298,500,000	3,650,000	109,500,000	102,200,000	0	143,656,700,000
10240012	Platte River	60,890	4,777,850,000	244,550,000	726,350,000	1,157,050,000	0	0	459,900,000	193,450,000	0	7,559,150,000
10240013	One Hundred and Two River	33,150	664,300,000	21,900,000	65,700,000	0	0	0	156,950,000	102,200,000	0	1,011,050,000
10270104	Kansas River	7,960	386,900,000	3,650,000	14,600,000	7,300,000	0	0	0	0	0	412,450,000
10280101	Upper Grand River	56,950	1,299,400,000	102,200,000	295,650,000	21,900,000	21,900,000	0	901,550,000	98,550,000	0	2,741,150,000
10280102	Thompson River	15,670	795,700,000	14,600,000	40,150,000	0	970,900,000	0	313,900,000	138,700,000	0	2,273,950,000
10280103	Medicine, Locust and Yellow Creeks	25,590	1,335,900,000	116,800,000	324,850,000	36,500,000	0	0	689,850,000	240,900,000	0	2,744,800,000
10280201	Upper Chariton River	5,840	222,650,000	10,950,000	25,550,000	3,650,000	0	0	153,300,000	36,500,000	0	452,600,000
10280202	Lower Chariton River	12,640	631,450,000	21,900,000	51,100,000	7,300,000	0	0	306,600,000	138,700,000	0	1,157,050,000
10280203	Little Chariton River	18,150	511,000,000	40,150,000	109,500,000	18,250,000	267,001,150,000	3,650,000	193,450,000	36,500,000	0	267,913,650,000
10290102	Marais des Cygnes River	10,950	500,050,000	3,650,000	36,500,000	0	0	0	94,900,000	21,900,000	0	657,000,000
10290103	Little Osage River	1,220	219,000,000	3,650,000	3,650,000	0	0	0	87,600,000	375,950,000	0	689,850,000
10290104	Marmaton River	15,470	631,450,000	10,950,000	7,300,000	0	0	0	219,000,000	1,525,700,000	0	2,394,400,000
10290105	Osage River	20,230	624,150,000	65,700,000	197,100,000	7,300,000	0	0	383,250,000	784,750,000	1,220,925,000,000	2,062,250,000
10290106	Sac River	83,720	8,424,000,000	372,300,000	1,032,950,000	547,500,000	0	0	828,550,000	1,708,200,000	233,797,100,000	10,913,500,000
10290107	Pomme de Terre River	31,880	1,105,950,000	135,050,000	401,500,000	54,750,000	0	0	470,850,000	105,850,000	0	2,273,950,000
10290108	South Grand River	86,660	5,179,350,000	189,800,000	474,500,000	87,600,000	104,846,250,000	3,650,000	609,550,000	751,900,000	0	112,142,600,000
10290109	Osage River (Lake of the Ozarks)	56,060	682,550,000	197,100,000	624,150,000	32,850,000	0	0	332,150,000	40,150,000	1,487,484,500,000	1,908,950,000
10290110	Niangua River	28,370	511,000,000	200,750,000	496,400,000	14,600,000	0	0	361,350,000	43,800,000	58,867,200,000	1,627,900,000
10290111	Lower Osage River	29,530	1,303,050,000	65,700,000	350,400,000	65,700,000	0	0	419,750,000	18,250,000	0	2,222,850,000
10290201	Upper Gasconade River	58,150	2,003,850,000	149,650,000	438,000,000	131,400,000	0	0	624,150,000	361,350,000	0	3,708,400,000

1990 USGS National Water-Use Information Program Summary Table-
Organized by hydrologic unit number
NOTE: Water use totals shown in gallons per year

Hydrologic Unit	Hydrologic Unit Name	Total Population	Public Supply	Commercial	Domestic	Industrial	Thermoelectric Power	Mining	Livestock	Irrigation	Hydroelectric Power	Total Water Use
10290202	Big Piney River	23,580	770,150,000	40,150,000	116,800,000	127,750,000	0	0	171,550,000	102,200,000	0	1,328,600,000
10290203	Lower Gasconade River	27,900	843,150,000	87,600,000	259,150,000	25,550,000	0	0	299,300,000	32,850,000	0	1,547,600,000
10300101	Missouri River (Clay/Jackson Counties to Little Chariton River)	815,260	38,043,950,000	824,900,000	2,449,150,000	4,639,150,000	132,407,400,000	18,250,000	759,200,000	335,800,000	0	179,477,800,000
10300102	Missouri River (Little Chariton River to Gasconade River)	243,230	8,843,950,000	233,600,000	671,600,000	142,350,000	15,957,800,000	0	1,200,850,000	810,300,000	0	27,860,450,000
10300103	Lamine River	47,820	1,445,400,000	102,200,000	288,350,000	65,700,000	0	0	474,500,000	47,450,000	0	2,423,600,000
10300104	Blackwater River	63,910	2,438,200,000	3,650,000	105,850,000	73,000,000	0	0	602,250,000	120,450,000	0	3,343,400,000
10300200	Missouri River (Gasconade to Mississippi River)	406,250	32,660,200,000	383,250,000	824,900,000	2,263,000,000	390,075,500,000	0	361,350,000	372,300,000	0	426,940,500,000
11010001	White River (above Table Rock Dam)	15,000	401,500,000	54,750,000	94,900,000	189,800,000	0	0	116,800,000	0	0	857,750,000
11010002	James River	211,040	4,204,800,000	365,000,000	1,109,600,000	678,900,000	72,087,500,000	0	616,850,000	65,700,000	0	79,128,350,000
11010003	White River (below Table Rock Dam)	36,570	1,054,850,000	193,450,000	569,400,000	51,100,000	0	0	394,200,000	73,000,000	1,816,605,000,000	2,336,000,000
11010006	White River (North Fork)	19,360	397,850,000	124,100,000	368,650,000	14,600,000	0	0	427,050,000	69,350,000	0	1,401,600,000
11010007	Black River	48,860	981,850,000	135,050,000	390,550,000	365,000,000	0	6,529,850,000	408,800,000	39,883,550,000	0	48,694,650,000
11010008	Current River	32,680	686,200,000	91,250,000	390,550,000	73,000,000	0	229,950,000	317,550,000	8,628,600,000	0	10,417,100,000
11010009	Fourche Creek	760	29,200,000	3,650,000	14,600,000	0	0	0	10,950,000	448,950,000	0	507,350,000
11010010	Spring River (Black River basin)	21,120	295,650,000	43,800,000	135,050,000	10,950,000	0	0	149,650,000	3,650,000	0	638,750,000
11010011	Eleven Point River	12,840	357,700,000	65,700,000	215,350,000	10,950,000	0	0	262,800,000	131,400,000	0	1,043,900,000
11070206	Lost Creek	6,660	142,350,000	25,550,000	73,000,000	14,600,000	0	0	32,850,000	18,250,000	0	306,600,000
11070207	Spring River (Arkansas River basin)	169,790	6,573,650,000	408,800,000	1,029,300,000	3,474,800,000	627,800,000	0	562,100,000	4,730,400,000	0	17,406,850,000
11070208	Elk River	21,100	1,047,550,000	127,750,000	346,750,000	281,050,000	0	0	295,650,000	87,600,000	0	2,186,350,000

Table 2

1990 USGS National Water-Use Information Program Summary Table-
Organized by hydrologic unit name
NOTE: Water use totals shown in gallons per year

Hydrologic Unit	Hydrologic Unit Name	Total Population	Public Supply	Commercial	Domestic	Industrial	Thermoelectric Power	Mining	Livestock	Irrigation	Hydroelectric Power	Total Water Use
10290202	Big Piney River	23,580	770,150,000	40,150,000	116,800,000	127,750,000	0	0	171,550,000	102,200,000	0	1,328,600,000
07140104	Big River	77,080	1,773,900,000	233,600,000	693,500,000	3,387,200,000	0	379,600,000	131,400,000	29,200,000	0	6,628,400,000
11010007	Black River	48,860	981,850,000	135,050,000	390,550,000	365,000,000	0	6,529,850,000	408,800,000	39,883,550,000	0	48,694,650,000
10300104	Blackwater River	63,910	2,438,200,000	3,650,000	105,850,000	73,000,000	0	0	602,250,000	120,450,000	0	3,343,400,000
07140103	Bourbeuse River	48,960	1,095,000,000	149,650,000	474,500,000	25,550,000	0	0	215,350,000	14,600,000	0	1,974,650,000
08020302	Cache River	680	40,150,000	3,650,000	10,950,000	0	0	0	3,650,000	1,989,250,000	0	2,047,650,000
07110008	Cuivre River	42,850	1,518,400,000	229,950,000	518,300,000	427,050,000	0	0	405,150,000	733,650,000	0	3,832,500,000
11010008	Current River	32,680	686,200,000	91,250,000	390,550,000	73,000,000	0	229,950,000	317,550,000	8,628,600,000	0	10,417,100,000
07110009	Dardenne/Peruque Creeks	157,110	3,759,500,000	401,500,000	489,100,000	219,000,000	154,880,450,000	0	18,250,000	146,000,000	0	159,913,800,000
07100009	Des Moines River	580	18,250,000	3,650,000	7,300,000	0	0	0	76,650,000	10,950,000	0	116,800,000
11010011	Eleven Point River	12,840	357,700,000	65,700,000	215,350,000	10,950,000	0	0	262,800,000	131,400,000	0	1,043,900,000
11070208	Elk River	21,100	1,047,550,000	127,750,000	346,750,000	281,050,000	0	0	295,650,000	87,600,000	0	2,186,350,000
11010009	Fourche Creek	760	29,200,000	3,650,000	14,600,000	0	0	0	10,950,000	448,950,000	0	507,350,000
07110001	Fox/Wyaconda Rivers	13,540	284,700,000	36,500,000	102,200,000	18,250,000	0	0	208,050,000	73,000,000	0	722,700,000
07140107	Headwater Diversion	35,300	1,660,750,000	135,050,000	430,700,000	40,150,000	0	0	284,700,000	1,292,100,000	0	3,843,450,000
11010002	James River	211,040	4,204,800,000	365,000,000	1,109,600,000	678,900,000	72,087,500,000	0	616,850,000	65,700,000	0	79,128,350,000
10270104	Kansas River	7,960	386,900,000	3,650,000	14,600,000	7,300,000	0	0	0	0	0	412,450,000
10300103	Lamine River	47,820	1,445,400,000	102,200,000	288,350,000	65,700,000	0	0	474,500,000	47,450,000	0	2,423,600,000
10280203	Little Chariton River	18,150	511,000,000	40,150,000	109,500,000	18,250,000	267,001,150,000	3,650,000	193,450,000	36,500,000	0	267,913,650,000
10290103	Little Osage River	1,220	219,000,000	3,650,000	3,650,000	0	0	0	87,600,000	375,950,000	0	689,850,000
08020204	Little River	97,790	3,905,500,000	135,050,000	357,700,000	485,450,000	1,485,550,000	0	135,050,000	37,032,900,000	0	43,537,200,000
11070206	Lost Creek	6,660	142,350,000	25,550,000	73,000,000	14,600,000	0	0	32,850,000	18,250,000	0	306,600,000
10280202	Lower Chariton River	12,640	631,450,000	21,900,000	51,100,000	7,300,000	0	0	306,600,000	138,700,000	0	1,157,050,000
10290203	Lower Gasconade River	27,900	843,150,000	87,600,000	259,150,000	25,550,000	0	0	299,300,000	32,850,000	0	1,547,600,000
08010100	Lower Mississippi River (Main Stem)	3,630	343,100,000	7,300,000	14,600,000	51,100,000	0	0	0	2,102,400,000	0	2,518,500,000
10290111	Lower Osage River	29,530	1,303,050,000	65,700,000	350,400,000	65,700,000	0	0	419,750,000	18,250,000	0	2,222,850,000
08020203	Lower St. Francis River	18,510	908,850,000	40,150,000	109,500,000	156,950,000	0	0	29,200,000	17,151,350,000	0	18,396,000,000
10290102	Marais des Cygnes River	10,950	500,050,000	3,650,000	36,500,000	0	0	0	94,900,000	21,900,000	0	657,000,000
10290104	Marmaton River	15,470	631,450,000	10,950,000	7,300,000	0	0	0	219,000,000	1,525,700,000	0	2,394,400,000
10280103	Medicine, Locust and Yellow Creeks	25,590	1,335,900,000	116,800,000	324,850,000	36,500,000	0	0	689,850,000	240,900,000	0	2,744,800,000
07140102	Meramec River	305,100	18,290,150,000	328,500,000	719,050,000	4,025,950,000	0	638,750,000	328,500,000	47,450,000	0	24,378,350,000
10240011	Missouri River (Andrew, Buchanan and Platte Counties)	114,160	4,263,200,000	120,450,000	368,650,000	390,550,000	138,298,500,000	3,650,000	109,500,000	102,200,000	0	143,656,700,000
10300101	Missouri River (Clay/Jackson Counties to Little Chariton River)	815,260	38,043,950,000	824,900,000	2,449,150,000	4,639,150,000	132,407,400,000	18,250,000	759,200,000	335,800,000	0	179,477,800,000
10300200	Missouri River (Gasconade to Mississippi River)	406,250	32,660,200,000	383,250,000	824,900,000	2,263,000,000	390,075,500,000	0	361,350,000	372,300,000	0	426,940,500,000
10240005	Missouri River (Holt and Atchison Counties)	11,960	306,600,000	25,550,000	80,300,000	58,400,000	0	0	175,200,000	2,299,500,000	0	2,945,550,000
10240001	Missouri River (Iowa to Nishnabotna River)	0	7,300,000	0	0	0	0	0	3,650,000	80,300,000	0	91,250,000
10300102	Missouri River (Little Chariton River to Gasconade River)	243,230	8,843,950,000	233,600,000	671,600,000	142,350,000	15,957,800,000	0	1,200,850,000	810,300,000	0	27,860,450,000
10240004	Missouri River (Nishnabotna River)	480	32,850,000	0	3,650,000	7,300,000	0	0	10,950,000	262,800,000	0	317,550,000
08020201	New Madrid Floodway	35,780	1,478,250,000	58,400,000	715,400,000	62,050,000	386,049,550,000	0	47,450,000	5,748,750,000	0	394,159,850,000
10290110	Niangua River	28,370	511,000,000	200,750,000	496,400,000	14,600,000	0	0	361,350,000	43,800,000	58,867,200,000	1,627,900,000
10240010	Nodaway River	5,320	386,900,000	29,200,000	91,250,000	3,650,000	0	0	222,650,000	135,050,000	0	888,700,000
07110002	North Fabius River	9,080	313,900,000	25,550,000	80,300,000	69,350,000	0	0	270,100,000	18,250,000	0	777,450,000
07110004	North River and Main Stem (Salt River to Missouri River)	51,950	1,025,650,000	76,650,000	240,900,000	1,197,200,000	0	0	390,550,000	164,250,000	0	3,095,200,000
10240013	One Hundred and Two River	33,150	664,300,000	21,900,000	65,700,000	0	0	0	156,950,000	102,200,000	0	1,011,050,000

1990 USGS National Water-Use Information Program Summary Table-
Organized by hydrologic unit name
NOTE: Water use totals shown in gallons per year

Hydrologic Unit	Hydrologic Unit Name	Total Population	Public Supply	Commercial	Domestic	Industrial	Thermoelectric Power	Mining	Livestock	Irrigation	Hydroelectric Power	Total Water Use
10290105	Osage River	20,230	624,150,000	65,700,000	197,100,000	7,300,000	0	0	383,250,000	784,750,000	1,220,925,000,000	2,062,250,000
10290109	Osage River (Lake of the Ozarks)	56,060	682,550,000	197,100,000	624,150,000	32,850,000	0	0	332,150,000	40,150,000	1,487,484,500,000	1,908,950,000
10240012	Platte River	60,890	4,777,850,000	244,550,000	726,350,000	1,157,050,000	0	0	459,900,000	193,450,000	0	7,559,150,000
10290107	Pomme de Terre River	31,880	1,105,950,000	135,050,000	401,500,000	54,750,000	0	0	470,850,000	105,850,000	0	2,273,950,000
10290106	Sac River	83,720	6,424,000,000	372,300,000	1,032,950,000	547,500,000	0	0	828,550,000	1,708,200,000	233,797,100,000	10,913,500,000
07110007	Salt River	11,550	441,650,000	36,500,000	65,700,000	463,550,000	0	0	266,450,000	397,850,000	257,419,900,000	1,671,700,000
07110005	Salt River (North Fork)	28,110	667,950,000	18,250,000	116,800,000	0	0	0	350,400,000	102,200,000	0	1,255,600,000
07110006	Salt River (South Fork)	48,940	1,533,000,000	69,350,000	186,150,000	153,300,000	0	0	405,150,000	1,368,750,000	0	3,715,700,000
07110003	South Fabius River	8,600	485,450,000	14,600,000	3,650,000	361,350,000	0	0	219,000,000	69,350,000	0	1,153,400,000
10290108	South Grand River	86,660	5,179,350,000	189,800,000	474,500,000	87,600,000	104,846,250,000	3,650,000	609,550,000	751,900,000	0	112,142,600,000
11070207	Spring River (Arkansas River basin)	169,790	6,573,650,000	408,800,000	1,029,300,000	3,474,800,000	627,800,000	0	562,100,000	4,730,400,000	0	17,406,850,000
11010010	Spring River (Black River basin)	21,120	295,650,000	43,800,000	135,050,000	10,950,000	0	0	149,650,000	3,650,000	0	638,750,000
10280102	Thompson River	15,670	795,700,000	14,600,000	40,150,000	0	970,900,000	0	313,900,000	138,700,000	0	2,273,950,000
10280201	Upper Chariton River	5,840	222,650,000	10,950,000	25,550,000	3,650,000	0	0	153,300,000	36,500,000	0	452,600,000
10290201	Upper Gasconade River	58,150	2,003,850,000	149,650,000	438,000,000	131,400,000	0	0	624,150,000	361,350,000	0	3,708,400,000
10280101	Upper Grand River	56,950	1,299,400,000	102,200,000	295,650,000	21,900,000	21,900,000	0	901,550,000	98,550,000	0	2,741,150,000
07140105	Upper Mississippi River (Ste. Genevieve to Ohio River)	64,460	1,664,400,000	98,550,000	310,250,000	32,850,000	0	0	321,200,000	657,000,000	0	3,084,250,000
07140101	Upper Mississippi River (St. Louis to Ste. Genevieve)	1,000,160	69,076,250,000	226,300,000	686,200,000	3,806,950,000	391,393,150,000	7,300,000	102,200,000	47,450,000	0	465,345,800,000
08020202	Upper St. Francis River	42,590	974,550,000	138,700,000	434,350,000	835,850,000	0	1,434,450,000	193,450,000	740,950,000	0	4,752,300,000
11010001	White River (above Table Rock Dam)	15,000	401,500,000	54,750,000	94,900,000	189,800,000	0	0	116,800,000	0	0	857,750,000
11010003	White River (below Table Rock Dam)	36,570	1,054,850,000	193,450,000	569,400,000	51,100,000	0	0	394,200,000	73,000,000	1,816,605,000,000	2,336,000,000
11010006	White River (North Fork)	19,360	397,850,000	124,100,000	388,650,000	14,600,000	0	0	427,050,000	69,350,000	0	1,401,600,000

APPENDIX 4

EIGHT-DIGIT HYDROLOGIC UNITS OF MISSOURI

Source: Hydrologic Unit Map, State of Missouri, USGS, 1974.

APPENDIX 5

LONG TERM AVERAGE DISCHARGES FOR STREAM GAGES IN MISSOURI

TABLE 1

Long Term Average Discharges for Stream Gages in Missouri (cubic feet per second)
Organized alphabetically by station name

"N/A" indicates no data available
(USGS data distributed by Hydrosphere, Inc.)

Station Number	Station Name	Start Year	End Year	Nmbr. of Years	Drainage Area (sq. mi.)	Hydrologic Unit	Oct. Avg.	Nov. Avg.	Dec. Avg.	Jan. Avg.	Feb. Avg.	Mar. Avg.	Apr. Avg.	May Avg.	Jun. Avg.	Jul. Avg.	Aug. Avg.	Sept. Avg.	Annual Avg.
07065500	Alley Spring At Alley Mo	1929	1980	27	0	11010008	92	108	122	138	148	175	200	183	141	114	97	93	134
07035500	Barnes Creek Near Fredericktown, Missouri	1956	1976	21	4	8020202	1	5	6	5	6	9	11	8	3	1	2	2	5
05502000	Bear Creek At Hannibal, Mo.	1939	1993	49	31	7110004	11	15	15	13	26	32	33	29	24	24	16	14	21
06931000	Beaver Creek Near Rolla, Mo.	1948	1955	8	14	10290203	15	7	8	20	21	25	15	16	17	8	3	4	13
06928700	Beeler Branch Near Cabool Mo	1968	1977	10	8	10290202	3	10	11	9	7	12	16	7	4	0.87	1	3	7
07012000	Behmke Branch Near Rolla Mo	1948	1959	12	1	7140102	0.69	0.33	0.49	0.97	1	2	1	2	0.99	0.79	0.35	0.24	0.89
06923500	Bennett Spring At Bennett Springs Mo	1929	1993	40	100	10290110	132	153	170	166	185	223	247	240	191	144	126	127	175
06922800	Big Buffalo Creek Near Stover,Mo.	1965	1977	13	24	10290109	20	16	18	18	18	29	39	34	25	13	6	19	21
07037000	Big Creek At Des Arc, Mo.	1987	1993	7	100	8020202	41	173	244	222	160	209	262	164	83	38	24	41	138
06921720	Big Creek Near Blairstown, Mo	1960	1975	16	414	10290108	293	215	220	278	207	431	557	408	579	167	95	351	315
07064500	Big Creek Near Yukon, Mo	1949	1976	28	8	11010008	4	8	9	9	10	16	20	12	4	4	1	3	8
06927200	Big Hollow Near Fulton Mo	1957	1972	16	4	10300102	2	1	1	2	3	4	6	4	4	2	0.67	4	3
06930000	Big Piney River Nr Big Piney, Mo	1922	1993	67	560	10290202	267	454	453	558	637	839	976	906	624	305	244	258	542
07018500	Big River At Byrnesville	1922	1993	72	917	7140104	336	668	904	916	1103	1440	1627	1376	806	502	297	368	859
07017200	Big River At Irondale, Mo	1965	1993	29	175	7140104	66	222	298	210	256	325	342	211	112	52	62	71	184
07018000	Big River Near Desoto, Missouri	1949	1983	35	718	7140104	252	448	741	675	860	1210	1254	996	469	436	254	261	651
07018100	Big River Near Richwoods Mo	1983	1993	11	735	7140104	370	1232	1309	874	1136	1281	1157	987	731	312	308	597	855
07067500	Big Spring Near Van Buren Mo	1922	1993	72	100	11010008	343	384	413	441	463	521	577	559	483	412	375	349	443
07062500	Black River At Leeper, Mo	1921	1993	73	987	11010007	470	681	1009	1155	1211	1492	1694	1460	1091	558	464	445	974
07063000	Black River At Poplar Bluff, Mo	1937	1993	55	1245	11010007	630	967	1407	1650	1690	2060	2268	1977	1297	790	641	604	1330
07061500	Black River Near Near Annapolis, Mo	1939	1993	55	484	11010007	266	615	696	610	730	995	1152	861	516	269	208	230	594
06908000	Blackwater River At Blue Lick, Missouri	1922	1993	68	1120	10300104	559	600	454	468	669	1052	1374	1086	1211	830	284	614	765
06907700	Blackwater River At Valley City Mo	1959	1973	15	547	10300104	300	210	178	274	269	594	984	599	782	557	125	549	451
06893566	Blue River At Coal Mine Rd At Kansas City, Mo	1981	1982	2	230	10300101	576	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1131	N/A	N/A	854
06893500	Blue River Near Kansas City, Mo.	1939	1993	55	188	10300101	129	97	93	96	121	193	264	236	272	174	80	171	160
06893520	Blue River Nr Gregory Blvd At Kansas City, Mo	1981	1982	2	198	10300101	1210	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1292	N/A	N/A	1280
07066550	Blue Spring Near Eminence, Mo.	1970	1971	2	0	11010008	136	129	92	145	159	131	101	112	88	75	74	83	105
07016500	Bourbeuse River At Union, Mo	1921	1993	73	808	7140103	317	506	675	625	771	1121	1237	1100	843	347	192	269	664
07016000	Bourbeuse River Near Spring Bluff Mo	1966	1982	17	608	7140103	3198	3541	2905	3616	4047	3386	4421	4594	4031	3260	2173	3487	3740
07015720	Bourbeuse River Nr High Gate Mo	1965	1993	29	135	7140103	50	156	214	136	179	230	232	165	103	39	34	57	132
07015000	Bourbeuse River Nr St. James Mo	1948	1982	35	21	7140103	9	10	14	17	22	33	26	30	15	9	3	5	16
07033800	Brewers C Nr Ironton, Mo.	1965	1966	2	2	8020202	0	N/A	0.26	1	3	1	7	3	0.05	N/A	0.11	0.5	1

Long Term Average Discharges for Stream Gages in Missouri (cubic feet per second)
Organized alphabetically by station name

"N/A" indicates no data available
(USGS data distributed by Hydrosphere, Inc.)

Station Number	Station Name	Start Year	End Year	Nmbr. of Years	Drainage Area (sq. mi.)	Hydrologic Unit	Oct. Avg.	Nov. Avg.	Dec. Avg.	Jan. Avg.	Feb. Avg.	Mar. Avg.	Apr. Avg.	May Avg.	Jun. Avg.	Jul. Avg.	Aug. Avg.	Sept. Avg.	Annual Avg.
06893560	Brush Creek At Kansas City Mo	1971	1979	9	15	10300101	8	4	4	3	4	13	7	10	11	7	6	23	8
06893560	Brush Creek At Kansas City Mo	1974	1975	2	15	10300101	N/A	0.21	6	5	2	2	3	N/A	3	3	N/A	N/A	2
06921740	Brushy Creek Near Blairstown Mo	1961	1975	15	1	10290108	0.89	0.9	0.93	1	0.93	2	2	2	1	0.52	0.59	1	1
07058000	Bryant Creek Near Tecumseh, Mo	1945	1985	41	570	11010006	240	421	541	510	631	841	969	869	526	362	234	227	530
06906600	Burge Branch Near Arrow Rock Mo	1960	1973	14	0.331	10300102	0.15	0.07	0.05	0.09	0.12	0.24	0.36	0.21	0.19	0.13	0.03	0.2	0.15
05509700	Calumet Creek Near Clarksville, Mo	1965	1972	8	16	7110004	15	5	10	9	10	9	21	14	16	12	8	11	12
07020870	Cape La Croix At Bloomfield Rd In Cape Girardeau	1979	1982	4	12	7140105	4	35	56	55	57	72	112	57	8	26	9	3	41
07020860	Cape La Croix At Highway 61 In Cape Girardeau Mo	1979	1982	4	12	7140105	0.73	14	13	24	23	33	25	21	7	10	3	0.73	15
07043000	Castor River At Aquilla, Mo	1946	1982	37	175	8020204	32	111	175	281	284	372	301	240	102	69	38	46	171
07021000	Castor River At Zalma, Mo	1920	1991	72	423	7140107	161	397	588	725	708	1034	1028	787	432	167	106	118	520
06910410	Cedar Creek Near Columbia Mo	1964	1991	18	45	10300102	32	13	29	35	34	62	58	64	50	28	16	22	36
06919500	Cedar Creek Near Pleasant View, Mo	1923	1993	49	420	10290106	179	338	304	265	394	584	512	455	353	253	86	197	325
07186400	Center Creek Near Carterville, Mo	1962	1991	30	232	11070207	113	258	223	181	218	354	333	272	230	122	63	104	205
06905000	Chariton River At Elmer, Mo.	1922	1930	9	1660	10280202	1385	1209	577	323	1157	1477	2263	606	1748	770	329	1364	1106
06904050	Chariton River At Livonia, Mo.	1974	1993	20	864	10280201	439	500	676	389	563	919	914	815	821	1112	661	601	704
06904500	Chariton River At Novinger Mo	1931	1993	61	1370	10280202	514	585	557	524	802	1459	1430	1240	1448	954	550	556	884
06905500	Chariton River Near Prairie Hill, Mo.	1929	1993	65	1870	10280202	734	832	763	742	1114	1945	2106	1862	2018	1449	709	769	1254
06918444	Chesapeake Spring At Chesapeake Mo	1966	1967	2	0	10290106	2	1	2	2	3	3	3	3	3	3	2	2	2
07037700	Clark Creek Near Piedmont Mo	1957	1976	20	4	8020202	0.82	4	4	5	5	9	10	7	2	2	0.99	2	4
06936500	Coldwater Cr At Hwy 67, Nr St Louis, Mo	1961	1965	4	44	10300200	28	32	30	25	32	66	53	87	52	39	32	29	42
05503800	Crooked Creek Near Paris Mo	1980	1993	14	80	7110005	32	77	72	24	71	87	69	100	67	99	30	56	65
06895000	Crooked River Near Richmond, Mo.	1948	1970	23	159	10300101	55	58	20	46	96	124	149	119	184	179	45	103	99
05514500	Culvre River Near Troy, Mo	1922	1993	67	903	7110008	432	509	538	497	842	1020	1185	973	698	580	290	503	671
05514500	Culvre River Near Troy, Mo	1991	1993	2	903	7110008	9	984	842	1152	454	1382	1840	911	377	2991	661	4570	1349
07068000	Current River At Doniphan,Mo.	1921	1993	73	2038	11010008	1621	2313	2719	2893	3087	3810	4605	4102	2972	1968	1677	1578	2772
07067000	Current River At Van Buren, Mo	1921	1993	73	1667	11010008	1072	1655	1924	2014	2218	2780	3397	3023	2113	1312	1089	1026	1963
07066500	Current River Near Eminence, Mo	1921	1976	56	1272	11010008	803	1160	1235	1477	1632	2053	2563	2332	1672	975	809	751	1451
05514800	Dardenne Creek At Cottleville Mo	1979	1982	4	N/A	7110009	8	35	11	20	114	72	144	73	34	135	18	25	56
07010086	Deer Cr At Big Bend, In Maplewood, Mo	1979	1982	4	37	7140101	49	73	30	10	43	47	104	71	69	93	44	26	53
07010044	Deer Cr At Warson Rd, In Ladue, Mo	1970	1981	5	N/A	7140101	5	8	5	4	15	11	10	18	15	16	10	4	10
05490600	Des Moines River At St. Francisville, Mo.	1978	1986	9	14300	7100009	5499	8117	7144	6116	10900	17000	17800	15900	17700	18200	11000	6456	12200
06923150	Dousinbury Cr On Jj Near Wall Street, Mo	1993	1993	1	36	10290110	N/A	N/A	N/A	N/A	N/A	N/A	37	36	52	7	3	305	74

Long Term Average Discharges for Stream Gages in Missouri (cubic feet per second)
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07017500	Dry Branch Near Bonne Terre, Missouri	1956	1976	21	3	7140104	0.41	2	3	3	4	6	6	5	2	0.79	0.49	0.84	3
06897000	East Fork Big Creek Near Bethany Mo	1934	1972	39	95	10280101	25	25	14	24	60	83	69	74	114	32	17	37	48
07061300	East Fork Black River At Lesterville, Mo	1960	1991	32	95	11010007	34	165	196	108	166	236	234	154	72	19	29	34	120
06893890	East Fork Little Blue River Nr Blue Springs, Mo.	1975	1993	19	34	10300101	24	16	17	13	16	33	47	52	44	21	22	25	28
06906300	East Fork Little Chariton R Nr Huntsville Mo	1963	1993	31	220	10280203	129	132	137	131	150	266	335	253	211	209	84	150	182
06906200	East Fork Little Chariton R Nr Macon Mo	1971	1993	23	112	10280203	67	73	100	67	62	150	189	173	97	104	69	82	103
07071500	Eleven Point River Near Bardley, Mo	1922	1993	72	793	11010011	417	566	716	802	840	1058	1318	1155	897	611	487	431	774
07070500	Eleven Point River Near Thomasville, Mo	1951	1977	27	361	11010011	26	85	90	88	113	164	243	193	93	57	29	25	100
05506800	Elk Fork Salt River Near Madison, Mo.	1969	1993	25	200	7110006	116	146	160	113	178	279	314	220	180	168	47	137	171
05506800	Elk Fork Salt River Near Madison, Mo.	1974	1974	1	200	7110006	168	52	343	534	239	178	31	650	1848	N/A	N/A	N/A	290
05507000	Elk Fork Salt River Near Paris, Mo.	1935	1982	23	262	7110006	86	94	97	148	210	343	318	310	369	186	72	48	190
07189000	Elk River Near Tiff City, Mo	1940	1994	55	872	11070208	437	727	787	679	868	1346	1665	1551	947	487	273	303	841
3843010904 41701	Estavelle At Busch Wildlife At Weldon Spring, Mo	1987	1987	1	0	0	0.42	0.14	0.33	0.37	0.23	0.56	0.32	N/A	N/A	0.14	0.01	N/A	0.24
06894500	E.F. Fishing R. At Excelsior Springs, Mo.	1951	1973	23	20	10300101	10	9	4	5	10	16	22	17	21	26	7	14	13
06906700	Flat C Nr Sedalia, Mo.	1961	1967	7	148	10300103	48	51	25	29	36	123	154	123	161	88	55	159	88
07068863	Fourche River Near Poynor, Mo.	1976	1984	9	87	11010009	21	70	225	86	126	252	194	111	72	38	32	19	103
05495000	Fox River At Wayland, Mo.	1922	1993	72	400	7100009	170	180	146	162	317	450	459	314	387	252	119	188	262
07064300	Fudge Hollow Nr Licking, Mo	1957	1976	20	2	11010008	0.1	0.3	0.19	0.21	0.18	0.24	0.33	0.48	0.19	0.15	0.08	0.19	0.22
06933500	Gasconade River At Jerome Mo	1903	1993	75	2840	10290203	1404	2235	2529	2420	2951	3986	4597	4231	3103	1583	1207	1314	2630
06928000	Gasconade River Near Hazlegreen, Missouri	1929	1972	44	1250	10290201	511	667	713	965	1164	1580	1778	1856	1139	556	294	372	964
06934000	Gasconade River Near Rich Fountain, Mo.	1922	1993	45	3180	10290203	1707	2274	2535	2866	3187	4437	5503	5061	3937	1858	1416	1492	3021
06928500	Gasconade River Near Waynesville, Missouri	1915	1972	58	1680	10290201	749	977	1049	1323	1580	2113	2600	2521	1793	754	684	600	1392
06897500	Grand River Near Gallatin Mo	1921	1993	73	2250	10280101	823	871	539	506	949	1742	1914	1736	2318	1668	555	1140	1228
06902000	Grand River Near Sumner Mo	1925	1993	68	6880	10280103	2725	2977	2080	1906	3529	5850	6649	5486	7369	4792	1809	3218	4025
07010155	Gravois Cr At Tesson Ferry Rd, Sappington, Mo	1979	1982	4	N/A	7140102	4	7	2	3	12	8	15	2	6	13	9	2	7
07011500	Green Acre Branch Near Rolla Mo	1948	1975	28	1	7140102	0.2	0.23	0.35	0.48	0.58	0.77	0.49	0.68	0.41	0.23	0.13	0.13	0.39
07071000	Greer Spring At Greer Mo	1922	1993	71	100	11010011	255	280	304	330	345	391	445	445	403	335	295	267	341
06924500	Hahatonka Sp At Hahatonka Mo	1923	1926	4	0	10290110	64	71	74	66	69	77	84	74	88	72	73	79	74
06902500	Hamilton Branch Near New Boston Mo	1956	1972	17	3	10280103	2	1	1	1	2	3	4	3	3	3	0.61	2	2
06910230	Hinkson Creek At Columbia, Mo.	1967	1991	20	70	10300102	30	23	31	38	51	89	80	99	76	52	18	20	50
07057800	Hodgson Mill Spring At Sycamore, Mo.	1966	1968	3	0	11010006	38	37	41	41	43	41	45	43	41	42	39	38	41
07066000	Jacks Fork At Eminence, Mo	1922	1993	72	398	11010008	222	395	457	477	550	702	838	726	467	257	206	206	458

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07065495	Jacks Fork River At Alley Spring, Mo	1993	1993	1	298	0	N/A	N/A	N/A	N/A	N/A	438	549	233	133	103	78	1007	351
06893880	Jackson County Lake Near Blue Springs, Mo.	1974	1983	10	26	10300101	12	14	8	20	27	38	57	59	74	14	17	14	30
06893880	Jackson County Lake Near Blue Springs, Mo.	1974	1974	1	26	10300101	N/A	N/A	34	44	0.23	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28
07052500	James River At Galena, Mo	1922	1993	72	987	11010002	497	837	979	897	1099	1505	1748	1583	1196	602	406	440	981
07052250	James River Near Boaz, Mo.	1972	1981	10	462	11010002	234	780	445	398	548	1253	930	731	466	324	147	307	545
07050700	James River Near Springfield, Mo.	1956	1993	38	246	11010002	106	246	317	214	264	423	408	385	204	117	41	127	237
07050580	James River Near Strafford, Mo.	1974	1986	13	165	11010002	61	219	266	129	208	332	298	185	176	60	31	81	170
06821000	Jenkins Branch At Gower Mo	1950	1976	27	3	10240012	2	1	0.48	0.68	1	2	2	3	3	2	0.68	2	2
07019570	Joachim Creek At Hematite, Mo.	1971	1971	1	95	7140101	19	18	16	21	62	N/A	25	56	N/A	N/A	N/A	N/A	28
07070000	Kings Creek Near Willow Springs Mo	1955	1987	13	5	11010011	0.17	0.24	0.22	0.35	0.61	0.83	1	2	0.31	0.48	0.08	0.05	0.6
06907000	Lamine River At Clifton City, Mo.	1922	1971	50	598	10300103	336	292	261	336	423	585	759	772	884	350	161	315	453
06906800	Lamine River Near Otterville, Missouri	1988	1993	6	543	10300103	15	624	533	283	341	617	730	1110	332	825	126	647	516
07015500	Lanes Fk Nr Rolla, Mo	1952	1971	20	0.221	7140103	0.07	0.08	0.22	0.16	0.27	0.38	0.31	0.44	0.2	0.11	0.05	0.1	0.2
06928200	Laquey Branch Near Hazlegreen Mo	1958	1972	15	2	10290201	0.79	0.71	2	1	1	2	3	3	0.86	0.64	0.16	0.75	1
05507600	Lick Creek At Perry Mo	1980	1993	14	104	7110007	14	99	103	41	90	90	86	97	53	103	27	67	72
06921200	Lindley Creek Near Polk, Mo	1957	1991	35	112	10290107	85	92	120	94	127	205	170	144	79	34	14	33	99
06821280	Line Creek At Riverside, Mo.	1976	1982	7	19	10240011	11	6	4	3	6	34	21	26	22	14	4	28	15
06931500	Little Beaver Cr Nr Rolla, Mo	1948	1975	28	6	10290203	3	4	4	6	7	10	9	9	6	3	2	2	5
07068510	Little Black River Below Fairdealing,Mo.	1980	1986	7	194	11010008	105	313	559	252	302	332	372	299	118	56	94	48	229
07068380	Little Black River Nr Grandin Mo	1980	1984	5	80	11010008	25	87	275	131	84	87	120	109	31	14	61	16	83
06894000	Little Blue River Near Lake City, Mo	1948	1993	46	184	10300101	135	101	88	92	121	199	231	240	263	144	94	161	156
06893790	Little Blue R. At Longview Road In Kans. City, M	1966	1975	10	47	10300101	53	23	35	45	35	72	82	83	115	15	11	39	50
06932000	Little Piney Creek At Newburg, Mo	1929	1993	65	200	10290203	98	131	153	148	175	225	250	258	206	100	82	88	159
06821150	Little Platte River At Smithville, Mo.	1965	1993	29	234	10240012	163	119	85	93	96	165	234	316	247	242	144	198	176
06821150	Little Platte River At Smithville, Mo.	1975	1975	1	234	10240012	89	175	22	39	122	N/A	N/A	N/A	15	3	3	71	57
07042000	Little River Ditch 1 Near Kennett Mo	1927	1979	53	235	8020204	104	238	376	772	719	758	758	558	380	188	113	102	421
07044000	Little River Ditch 251 Near Kennett Mo	1927	1979	53	883	8020204	251	448	637	1058	1042	1203	1177	921	678	401	276	243	693
07042500	Little River Ditch 251 Near Lilbourn, Mo.	1946	1991	46	235	8020204	138	257	386	461	542	537	467	461	292	207	138	122	333
07046000	Little River Ditch 259 Near Kennett Mo	1927	1979	53	89	8020204	29	78	121	230	208	217	212	153	95	48	28	22	120
07045000	Little River Ditch 66 Near Kennett Mo	1927	1979	53	N/A	8020204	119	258	413	636	628	723	772	552	363	208	134	126	410
07045500	Little River Ditch 66A Near Kennett, Mo.	1927	1965	39	N/A	8020204	4	22	18	123	74	90	101	66	59	10	2	0.88	48
07041000	Little River Ditch 81 Near Kennett Mo	1927	1979	53	111	8020204	74	134	185	313	300	320	332	261	214	135	82	72	201

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07043500	Little River Ditch No 1 Near Morehouse, Mo.	1946	1991	46	450	8020204	177	427	657	772	898	961	878	741	383	267	180	178	541
06918800	Little Sac River At Aldrich, Mo.	1967	1968	2	304	10290106	356	354	922	386	623	613	257	205	146	45	37	27	286
06918740	Little Sac River Near Morrisville, Mo	1968	1993	26	237	10290106	126	329	325	241	283	488	396	285	195	80	37	220	250
07035000	Little St. Francis River At Fredericktown, Mo.	1939	1993	12	91	8020202	41	198	183	134	163	212	171	172	86	19	35	28	119
06901500	Locust Creek Near Linneus, Mo	1929	1972	44	550	10280103	169	207	146	190	304	476	589	458	692	284	137	169	318
06901000	Locust Creek Near Milan, Mo.	1922	1933	12	225	10280103	171	236	90	77	124	189	283	70	226	102	121	148	153
07068540	Logan Creek At Oxly Mo	1980	1984	5	38	11010008	5	37	109	62	45	43	64	50	13	6	20	4	37
05513500	Lost Creek At Elsberry, Mo.	1955	1961	7	12	7110004	4	1	0.79	1	4	7	12	16	8	8	3	0.9	6
07188500	Lost Creek At Seneca, Mo	1949	1959	11	42	11070206	15	14	10	16	28	36	41	57	46	34	21	19	28
06935500	Loutre River At Mineola, Mo.	1948	1967	20	202	10300200	64	30	26	82	123	205	204	130	122	112	18	62	98
06893793	L. Blue R. Bl Longview D.S. At Kansas City,Mo.	1975	1993	19	50	10300101	35	29	23	18	30	45	51	70	60	29	17	37	37
07005000	Maline Cr At Bellefontaine, Bellefontaine Nbr,Mo	1979	1981	3	N/A	7140101	29	24	23	33	77	177	871	47	38	41	50	23	153
07010500	Maramec Spring Near St. James	1922	1986	29	0	7140102	109	140	160	138	164	183	219	196	170	128	117	107	152
06927000	Maries River At Westphalia, Mo.	1948	1971	24	257	10290111	122	81	133	191	245	361	356	402	352	145	55	101	213
06900000	Medicine Creek Near Galt, Mo	1922	1991	68	225	10280103	102	96	70	71	143	241	252	201	265	135	71	99	145
07010350	Meramec River At Cook Station, Mo	1966	1982	17	199	7140102	36	100	113	135	148	207	221	163	63	34	27	32	106
07017000	Meramec River At Robertsville, Mo.	1940	1951	12	2673	7140102	1613	1600	1613	2747	2778	3590	4705	4014	4015	2037	1046	1118	2568
07019000	Meramec River Near Eureka, Mo	1974	1974	1	3788	7140102	995	5377	7350	8189	7654	8432	6736	4876	N/A	N/A	N/A	N/A	6584
07019000	Meramec River Near Eureka, Mo	1904	1993	75	3788	7140102	1434	2376	3070	3154	3840	5161	6146	5090	3570	1930	1178	1487	3202
07013000	Meramec River Near Steelville, Mo	1923	1993	71	781	7140102	286	466	587	566	652	870	1041	951	735	348	265	287	587
07014500	Meramec River Near Sullivan, Mo.	1922	1993	62	1475	7140102	590	984	1260	1215	1425	1905	2313	1931	1316	724	536	556	1227
05497500	Middle Fabius River Near Baring, Mo.	1936	1960	25	185	7110002	57	31	53	75	172	205	189	127	191	77	38	36	103
05498000	Middle Fabius River Near Monticello, Mo.	1946	1993	48	393	7110002	168	183	171	205	315	473	486	373	310	330	123	172	275
07068250	Middle Fork L Black R At Grandin Mo	1981	1984	4	7	11010008	0.33	8	29	13	4	9	10	10	1	0.15	6	3	8
06906470	Middle Fork Little Chariton R Bl Salisbury, Mo.	1965	1970	6	201	10280203	126	73	50	150	118	165	382	256	348	354	47	153	185
05506190	Middle Fork Salt River At Duncans Bridge Mo.	1981	1982	2	200	7110006	10	146	45	113	365	214	81	530	508	1338	40	7	257
05506500	Middle Fork Salt River At Paris, Mo.	1940	1993	54	356	7110006	170	183	174	169	270	440	464	363	314	283	102	150	257
07057360	Middle Indian Creek Near Cabool, Mo.	1987	1987	1	5	11010006	3	0.23	0.2	0.19	6	3	3	0.12	0.26	0.12	0.1	N/A	1
06816000	Mill Creek At Oregon Mo	1950	1976	27	5	10240005	2	1	1	1	2	2	2	4	4	3	2	2	2
07010000	Mississippi River At St Louis Mo	1933	1993	61	97000	7140101	135900	140000	121600	114300	141300	230400	305400	280300	259600	218000	142300	138300	186000
06909000	Missouri River At Boonville, Mo.	1926	1993	68	501700	10300102	52900	48800	33700	28900	41300	66100	88000	80500	99300	83900	55700	56800	61300
06934500	Missouri River At Hermann, Mo	1929	1993	65	524200	10300200	63700	63700	48900	43400	57600	89700	115000	108400	120400	99100	64700	66200	78400

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06893000	Missouri River At Kansas City Mo	1929	1993	65	485200	10300101	45800	41000	27100	23100	32200	53700	69400	65400	82600	70600	49400	49400	50900
06818000	Missouri River At St. Joseph, Mo.	1929	1993	65	420300	10240011	38500	34800	22300	19700	26500	44500	57200	51800	64900	55600	41500	40600	41500
06895500	Missouri River At Waverly Mo	1929	1993	65	487200	10300101	45900	41100	27900	23700	32800	53800	71800	66700	83800	72800	49700	49000	51600
06909500	Moniteau Creek Near Fayette, Mo.	1948	1969	22	81	10300102	21	21	19	32	51	62	63	44	52	53	12	14	37
06910500	Moreau River Near Jefferson City, Mo	1948	1975	27	561	10300102	311	224	221	359	422	652	534	542	611	333	119	289	385
06916655	Mulberry Creek Nr Amoret,Mo	1982	1982	1	N/A	10290102	N/A	720	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	720
06906000	Mussel Fork Near Musselfork, Missouri	1949	1990	32	267	10280202	163	158	169	143	243	318	463	335	315	245	71	156	230
06923000	Niangua Branch At Marshfield Mo	1950	1957	8	1	10290110	0.43	0.7	0.32	0.18	0.79	0.79	1	1	0.7	0.38	0.19	0.11	0.56
06925000	Niangua R Nr Roach Mo	1923	1930	8	698	10290110	658	745	830	701	706	1026	1574	1395	1618	535	913	527	940
06923250	Niangua River At Windyville, Missouri	1991	1993	3	377	10290110	35	563	536	370	306	349	328	313	378	108	53	948	363
06924000	Niangua River Near Decaturville, Mo.	1930	1969	40	627	10290110	423	451	462	541	647	873	1022	1078	849	455	350	393	629
06817500	Nodaway River Near Burlington Jct, Mo	1922	1984	63	1240	10240010	315	316	236	263	568	991	785	850	1148	523	349	455	566
06817700	Nodaway River Near Grahm	1987	1993	7	1380	10240010	529	585	711	450	575	1033	1260	1409	1451	2528	951	1404	1076
05497000	North Fabius River At Monticello, Mo	1922	1993	72	452	7110002	188	202	180	194	342	468	516	380	415	310	136	197	293
05497000	North Fabius River At Monticello, Mo	1981	1981	1	452	7110002	N/A	N/A	N/A	N/A	N/A	N/A	582	1114	71	N/A	N/A	N/A	959
05498500	North Fabius River At Taylor, Mo.	1931	1941	11	930	7110002	157	427	285	342	538	634	714	871	875	268	342	163	467
07058500	North Fork River At Tecumseh	1922	1944	23	1157	11010006	796	985	1074	1201	1329	1439	1944	1862	1593	790	703	635	1194
07057500	North Fork River Near Tecumseh, Mo	1945	1993	49	561	11010006	404	623	720	735	852	1055	1250	1124	776	551	415	428	743
07068300	North Prong L Black R Nr Grandin Mo	1980	1984	5	39	11010008	7	42	141	60	35	43	50	39	10	6	20	7	37
05500500	North River At Bethel, Mo	1937	1974	38	58	7110004	27	20	18	36	54	75	82	42	53	35	22	25	41
05501000	North River At Palmyra, Mo	1935	1993	59	373	7110004	160	180	179	181	308	458	466	445	324	264	110	138	268
07052050	N. F. Wilson Ck At Hwy 13 And 160,Springfield,Mo	1973	1977	5	5	11010002	6	6	6	6	6	10	6	659	8	7	6	9	57
05503000	Oak Dale Branch Near Emden, Mo	1955	1976	22	3	7110005	2	1	2	3	4	5	4	4	4	3	1	2	3
06918700	Oak Grove Br Nr Brighton, Mo	1956	1975	20	1	10290106	0.44	1	1	0.68	1	2	2	1	0.49	0.65	0.05	0.4	0.97
06819500	One Hundred And Two River At Maryville Mo	1933	1991	59	515	10240013	149	118	82	102	234	419	336	410	478	219	134	168	237
06819500	One Hundred And Two River At Maryville Mo	1974	1975	2	515	10240013	N/A	N/A	17	12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7
06927800	Osage Fork Gasconade River At Drynob, Mo.	1962	1982	21	404	10290201	130	273	283	281	358	515	489	449	265	133	71	143	280
06918070	Osage River Above Schell City, Mo.	1980	1993	14	5410	10290105	6737	5183	4414	2688	4817	7924	6729	6272	7708	5907	2530	2175	5378
06920500	Osage River At Osceola, Mo	1917	1978	60	8220	10290105	3919	3928	2809	3459	4143	6687	9366	8193	8480	4989	2841	3609	5194
06922500	Osage River At Warsaw, Mo.	1926	1931	6	11500	10290109	9748	7962	5700	5779	7955	8159	21500	16100	15400	4280	9006	3904	9599
06926000	Osage River Near Bagnell, Missouri	1925	1993	69	14000	10290111	7283	8266	8081	8192	9934	13500	16900	15400	14400	8822	5302	5919	10100
06926500	Osage River Near St. Thomas, Missouri	1931	1993	63	14500	10290111	7012	8532	8491	8648	10500	14500	16800	16000	15200	10000	5246	6354	10600

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06926500	Osage River Near St. Thomas, Missouri	1979	1980	2	14500	10290111	693	2711	2830	N/A	N/A	N/A	N/A	N/A	N/A	8709	2621	2876	2947
06922450	Osage R. Bl Harry S. Truman Dam At Warsaw, Mo	1982	1993	10	7856	10290109	8595	11200	16300	10900	10400	16000	17300	15700	12800	6362	5995	4382	11300
06929315	Paddy Creek Above Slabtown Spring, Mo	1993	1993	1	34	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	1	1	139	43
06910000	Petite Saline Creek Near Boonville, Mo.	1948	1967	20	182	10300102	65	45	28	64	103	144	140	137	168	125	71	96	99
06818900	Platte R At Ravenwood Mo	1958	1971	14	486	10240012	131	148	68	152	337	511	344	399	436	234	119	261	261
06821190	Platte River At Sharps Station, Mo	1979	1993	15	2380	10240012	1286	910	1288	669	1370	2407	2770	3129	2747	3548	1275	1817	1947
06820500	Platte River Near Agency, Mo.	1925	1993	67	1760	10240012	661	542	379	389	821	1389	1465	1480	1950	1207	462	961	972
07019790	Plattin Creek At Plattin, Mo.	1966	1973	8	66	7140101	11	52	71	55	64	63	122	71	23	25	15	14	49
06921325	Pomme De Terre Lake Near Hermitage Mo	1973	1973	1	611	10290107	231600	271900	250300	257000	256000	329800	441600	387100	255700	238700	234000	232700	267200
06921500	Pomme De Terre River At Hermitage, Mo.	1922	1965	44	655	10290107	370	369	382	476	561	867	1083	1044	850	400	357	287	587
06921000	Pomme De Terre River Near Bolivar, Mo.	1951	1969	19	225	10290107	95	110	148	121	223	286	299	290	171	181	35	79	170
06921350	Pomme De Terre River Near Hermitage, Mo.	1960	1993	34	615	10290107	241	510	716	544	590	871	877	842	513	310	105	138	520
06921070	Pomme De Terre River Near Polk, Mo	1969	1993	25	276	10290107	156	363	381	273	336	563	493	331	218	80	42	184	284
07010016	River Des Peres At Hafner Pl, University City,Mo	1979	1981	3	6	7140101	3	2	1	0.93	8	5	13	4	4	5	2	6	5
07050150	Roaring River Spring Near Cassville Mo	1966	1968	3	0	11010001	19	23	32	33	45	45	45	37	29	27	28	25	32
06893600	Rock Creek At Independence Mo	1967	1978	10	5	10300101	6	2	2	2	2	5	5	7	7	3	2	7	4
07065000	Round Spring At Round Spring Mo	1929	1980	26	0	11010008	25	35	42	49	53	68	81	73	48	36	28	27	47
06935000	Rumbo Branch At Danville, Mo.	1953	1958	6	1	10300200	0.23	0.01	0.01	0.25	0.69	0.77	1	1	1	2	0.11	0.63	0.85
06919020	Sac River At Highway J Below Stockton Mo	1974	1993	20	1292	10290106	554	647	1210	1375	1220	1598	1928	1647	1371	1057	850	949	1200
06919900	Sac River Near Caplinger Mills, Mo.	1975	1993	19	1810	10290106	954	1260	1788	1655	1817	2401	2515	2222	1782	1291	937	1220	1652
06918440	Sac River Near Dadeville, Mo	1966	1993	28	257	10290106	127	292	336	247	293	452	386	302	212	119	65	125	244
06919000	Sac River Near Stockton, Mo	1921	1990	70	1160	10290106	552	646	763	904	986	1263	1793	1673	1414	840	619	589	1001
07020270	Saline Creek Near Minnith Mo	1980	1982	3	83	7140105	9	12	20	11	30	18	16	141	98	28	11	8	28
05502300	Salt River At Hagers Grove, Mo.	1974	1993	20	365	7110005	192	346	243	106	321	474	428	445	271	421	95	142	289
05507800	Salt River Near Center Mo	1980	1993	14	2350	7110007	728	1529	2254	1190	1663	2715	2373	2266	2306	2350	1347	1363	1841
05503500	Salt River Near Hunnewell, Mo.	1931	1988	19	626	7110005	341	554	462	211	623	612	575	717	592	383	314	169	461
05507500	Salt River Near Monroe City, Mo.	1940	1981	42	2230	7110007	988	743	715	1145	1508	2707	2908	2001	1971	1351	592	845	1454
05508000	Salt River Near New London, Mo	1923	1993	71	2480	7110007	1037	1109	1158	1258	1862	2820	3061	2390	2401	1582	933	1076	1721
05502500	Salt River Near Shelbina, Mo.	1934	1993	46	481	7110005	137	172	151	206	343	463	503	407	476	362	132	196	294
07019690	Sandy Creek Near Pevely, Mo.	1966	1973	7	33	7140101	8	11	25	13	21	26	58	32	7	3	30	18	21
06908500	Shiloh Branch Near Marshall, Mo.	1952	1965	14	3	10300104	0.95	0.7	0.66	0.53	1	2	2	2	1	2	0.76	2	1
07187500	Shoal C Nr Joplin Mo	1924	1941	18	458	11070207	265	228	280	319	331	339	695	575	754	321	357	307	400

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07187000	Shoal Creek Above Joplin, Missouri	1942	1993	52	427	11070207	286	394	360	322	381	552	652	701	555	352	221	260	419
06893670	Shoal Creek At Claycomo, Missouri	1975	1982	8	30	10300101	12	7	5	2	6	21	18	26	30	16	7	25	15
06899700	Shoal Creek Near Braymer Mo	1958	1978	21	391	10280102	155	182	85	167	247	349	394	380	377	223	93	274	243
06894680	Snlabar Creek Near Tarsney Mo	1970	1982	11	29	10300101	13	14	45	17	21	47	37	36	13	14	0.77	44	25
05500000	South Fabius River Near Taylor, Mo	1935	1993	59	620	7110003	270	298	266	290	497	719	741	634	490	406	172	216	416
06907500	South Fork Blackwater River Near Elm, Mo.	1954	1980	27	17	10300104	10	5	5	7	9	17	23	17	15	12	4	13	11
05504800	South Fork Salt River Above Santa Fe	1987	1993	7	233	7110006	69	98	144	95	140	237	189	237	109	133	55	274	148
05504800	South Fork Salt River Above Santa Fe	1991	1993	2	233	7110006	19	243	203	238	113	287	439	282	54	388	91	451	234
05505000	South Fork Salt River At Santa Fe, Mo.	1940	1986	41	298	7110006	105	138	127	109	216	324	339	262	230	185	54	110	183
05504900	South Fork Salt River Near Santa Fe, Mo.	1968	1975	8	295	7110006	327	116	207	335	285	466	459	450	464	406	70	184	310
06921590	South Grand River At Archie, Mo	1970	1986	17	256	10290108	217	266	211	198	269	478	459	457	542	116	98	312	301
06921600	South Grand River At Urich, Mo.	1961	1969	9	670	10290108	232	381	236	256	297	475	700	652	1105	207	121	690	444
06922000	South Grand River Near Brownington, Mo.	1921	1971	51	1660	10290108	750	691	445	620	799	1265	2025	1677	2071	1005	490	856	1055
06921760	South Grand River Near Clinton, Mo	1985	1993	9	1270	10290108	1862	1203	1315	638	565	1401	1663	1899	767	1727	550	803	1195
05508805	Spencer Cr Below Plum Cr Nr Frankford Mo	1976	1993	18	206	7110007	59	196	224	89	197	286	243	261	94	191	64	120	169
05508800	Spencer Creek Nr Frankford Mo	1980	1980	1	200	7110007	39	1	0.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
07185765	Spring River At Carthage, Mo	1967	1981	15	425	11070207	225	501	389	331	429	701	545	483	436	273	136	230	389
07185700	Spring River At Larussell, Mo.	1957	1982	26	306	11070207	163	271	212	184	226	385	368	393	358	205	113	142	251
07186000	Spring River Near Waco, Mo	1924	1993	70	1164	11070207	652	901	727	705	914	1217	1415	1474	1389	710	457	599	929
07185500	Stahl Creek Near Miller Mo	1950	1977	28	4	11070207	3	4	2	2	3	5	4	4	4	2	0.58	1	3
06925200	Starks Creek At Preston Mo	1956	1977	22	4	10290110	3	3	4	4	4	8	6	6	3	1	0.44	2	4
0690634025	Stinking Creek Near Calleo Mo	1984	1984	1	N/A	10280203	N/A	N/A	N/A	N/A	N/A	10	14	N/A	N/A	N/A	N/A	N/A	13
07040000	St. Francis River At Fisk, Mo	1928	1941	14	1370	8020203	371	645	1228	2552	1695	2163	2598	1965	1436	522	293	260	1309
07039500	St. Francis River At Wappapello, Mo.	1941	1993	53	1311	8020202	394	899	1913	2384	2290	2715	2902	2461	1357	730	393	408	1567
07035800	St. Francis River Near Mill Creek, Mo	1988	1993	6	505	8020202	74	616	1074	994	895	934	1005	866	247	79	74	223	589
07037500	St. Francis River Near Patterson, Mo	1921	1993	73	956	8020202	366	958	1326	1468	1554	2163	2314	1708	923	330	219	256	1126
07034000	St. Francis River Near Roselle, Mo	1987	1993	7	234	8020202	46	242	460	340	367	406	414	347	99	41	39	125	243
07036100	St. Francis River Near Saco,Mo.	1983	1993	11	664	8020202	355	1710	1573	1151	1338	1588	1390	1213	692	102	176	201	935
06813000	Tarkio River At Fairfax Mo	1922	1991	70	508	10240005	131	117	94	98	185	292	252	296	420	265	166	186	208
06896500	Thompson Branch Near Albany Mo	1956	1972	17	6	10280101	3	2	0.54	1	3	4	3	5	4	3	0.58	6	3
06898100	Thompson River At Mount Moriah Mo	1960	1977	18	891	10280102	337	361	207	271	539	984	912	726	745	405	143	574	516
06899500	Thompson River At Trenton Mo	1929	1993	65	1670	10280102	603	685	496	478	903	1619	1700	1584	1791	1109	548	755	1021

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07057350	Tributary To Middle Indian Creek Near Cabool, Mo	1987	1987	1	1	11010006	1	22	0.16	0.21	2	1	0.97	0.05	0	0.04	N/A	N/A	3
07186500	Turkey Creek At Joplin, Mo	1933	1939	7	33	11070207	17	11	13	18	11	17	19	28	34	8	5	9	16
07186600	Turkey Creek Near Joplin, Mo	1964	1973	10	42	11070207	34	40	30	30	33	40	60	47	56	27	23	37	38
06918460	Turnback Creek Above Greenfield, Mo	1965	1993	29	252	10290106	139	314	327	256	321	480	426	336	254	156	96	150	270
0690633910	Twenty-Five Mine Discharge Near Keota Mo	1984	1984	1	N/A	10280203	0.54	0.67	0.66	N/A	N/A	0.9	0.91	0.8	0.84	N/A	N/A	N/A	0.74
06916654	Unnamed Trib To Mulberry Ck Nr Amoret, Mo	1982	1982	1	N/A	10290102	N/A	216	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	216
06926200	Van Cleve Branch Near Meta Mo	1956	1972	17	1	10290111	0.37	0.2	0.44	0.3	0.41	0.77	1	1	0.58	0.3	0.06	0.36	0.49
06896000	Wakenda Creek At Carrollton, Mo.	1948	1970	23	248	10300101	142	83	35	69	140	175	168	153	244	223	135	141	143
06899000	Weldon River At Mill Grove Mo	1929	1972	44	494	10280102	137	162	94	136	252	394	399	379	527	163	164	173	248
06898500	Weldon River Near Mercer, Mo.	1940	1959	20	246	10280102	54	38	38	66	138	204	220	262	405	95	101	43	138
06812500	West Tarkio C N Westboro Mo	1934	1940	7	105	10240005	69	36	23	28	336	598	105	258	463	183	85	97	192
06902200	West Yellow Creek Near Brookfield Mo	1959	1977	19	135	10280103	64	46	38	87	83	172	220	182	115	81	26	95	100
06820000	White Cloud Creek Nr Maryville	1949	1970	22	6	10240013	2	1	0.55	2	3	4	4	5	7	5	2	3	3
07053500	White River Near Branson, Mo.	1952	1992	41	4022	11010003	1613	2795	3860	3517	3947	5330	5983	5898	4014	3248	2711	1999	3742
07053000	White River Near Reeds Spring, Mo.	1938	1952	15	3617	11010003	1699	3658	3046	4037	6425	6536	8857	9232	4476	2203	1363	1029	4382
06933000	Wilkins Spring Near Newburg, Mo.	1953	1959	7	0	10290203	6	5	6	6	6	8	8	8	7	7	6	6	6
07052000	Wilson Creek At Scenic Drive In Springfield, Mo.	1933	1977	12	18	11010002	14	18	14	23	22	27	26	31	41	14	11	49	24
07052150	Wilson Creek Below Springfield, Mo.	1967	1972	6	47	11000002	48	47	64	37	38	45	41	39	30	23	20	37	38
07052160	Wilsons Creek Nr Battlefield Mo	1968	1982	14	55	11010002	61	115	80	78	89	150	123	109	99	63	50	61	90
07052100	Wilsons Creek Nr Springfield Mo	1972	1982	11	31	11000002	19	28	14	13	16	39	33	36	34	16	11	17	23
05496500	Wyaconda R Nr Canton Mo	1922	1932	11	447	7110001	407	385	170	166	378	432	527	131	524	206	176	257	312
05496000	Wyaconda River Above Canton, Mo	1933	1993	54	393	7110001	139	171	164	156	334	419	413	352	363	291	134	177	259
06903000	Yellow Creek Near Rothville, Mo.	1929	1951	7	405	10280103	118	313	117	256	340	211	505	180	732	178	46	77	262
05506000	Youngs Creek Near Mexico, Mo.	1937	1982	36	67	7110006	25	19	18	32	48	71	70	61	80	70	19	23	45

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05490600	Des Moines River At St. Francisville, Mo.	1978	1986	9	14300	7100009	5499	8117	7144	6116	10900	17000	17800	15900	17700	18200	11000	6456	12200
05495000	Fox River At Wayland, Mo.	1922	1993	72	400	7100009	170	180	146	162	317	450	459	314	387	252	119	188	262
05496000	Wyaconda River Above Canton, Mo	1933	1993	54	393	7110001	139	171	164	156	334	419	413	352	363	291	134	177	259
05496500	Wyaconda R Nr Canton Mo	1922	1932	11	447	7110001	407	385	170	166	378	432	527	131	524	206	176	257	312
05497000	North Fabius River At Monticello, Mo	1981	1981	1	452	7110002	N/A	N/A	N/A	N/A	N/A	N/A	582	1114	71	N/A	N/A	N/A	959
05497000	North Fabius River At Monticello, Mo	1922	1993	72	452	7110002	188	202	180	194	342	468	516	380	415	310	136	197	293
05497500	Middle Fabius River Near Baring, Mo.	1936	1960	25	185	7110002	57	31	53	75	172	205	189	127	191	77	38	36	103
05498000	Middle Fabius River Near Monticello, Mo.	1946	1993	48	393	7110002	168	183	171	205	315	473	486	373	310	330	123	172	275
05498500	North Fabius River At Taylor, Mo.	1931	1941	11	930	7110002	157	427	285	342	538	634	714	871	875	268	342	163	467
05500000	South Fabius River Near Taylor, Mo	1935	1993	59	620	7110003	270	298	266	290	497	719	741	634	490	406	172	216	416
05500500	North River At Bethel, Mo	1937	1974	38	58	7110004	27	20	18	36	54	75	82	42	53	35	22	25	41
05501000	North River At Palmyra, Mo	1935	1993	59	373	7110004	160	180	179	181	308	458	466	445	324	264	110	138	268
05502000	Bear Creek At Hannibal, Mo.	1939	1993	49	31	7110004	11	15	15	13	26	32	33	29	24	24	16	14	21
05502300	Salt River At Hagers Grove, Mo.	1974	1993	20	365	7110005	192	346	243	106	321	474	428	445	271	421	95	142	289
05502500	Salt River Near Shelbina, Mo.	1934	1993	46	481	7110005	137	172	151	206	343	463	503	407	476	362	132	196	294
05503000	Oak Dale Branch Near Emden, Mo	1955	1976	22	3	7110005	2	1	2	3	4	5	4	4	4	3	1	2	3
05503500	Salt River Near Hunnewell, Mo.	1931	1988	19	626	7110005	341	554	462	211	623	612	575	717	592	383	314	169	461
05503800	Crooked Creek Near Paris Mo	1980	1993	14	80	7110005	32	77	72	24	71	87	69	100	67	99	30	56	65
05504800	South Fork Salt River Above Santa Fe	1991	1993	2	233	7110006	19	243	203	238	113	287	439	282	54	388	91	451	234
05504800	South Fork Salt River Above Santa Fe	1987	1993	7	233	7110006	69	98	144	95	140	237	189	237	109	133	55	274	148
05504900	South Fork Salt River Near Santa Fe, Mo.	1968	1975	8	295	7110006	327	116	207	335	285	466	459	450	464	406	70	184	310
05505000	South Fork Salt River At Santa Fe, Mo.	1940	1986	41	298	7110006	105	138	127	109	216	324	339	262	230	185	54	110	183
05506000	Youngs Creek Near Mexico, Mo.	1937	1982	36	67	7110006	25	19	18	32	48	71	70	61	80	70	19	23	45
05506190	Middle Fork Salt River At Duncans Bridge Mo.	1981	1982	2	200	7110006	10	146	45	113	365	214	81	530	508	1338	40	7	257
05506500	Middle Fork Salt River At Paris, Mo.	1940	1993	54	356	7110006	170	183	174	169	270	440	464	363	314	283	102	150	257
05506800	Elk Fork Salt River Near Madison, Mo.	1969	1993	25	200	7110006	116	146	160	113	178	279	314	220	180	168	47	137	171
05506800	Elk Fork Salt River Near Madison, Mo.	1974	1974	1	200	7110006	168	52	343	534	239	178	31	650	1848	N/A	N/A	N/A	290
05507000	Elk Fork Salt River Near Paris, Mo.	1935	1982	23	262	7110006	86	94	97	148	210	343	318	310	369	186	72	48	190
05507500	Salt River Near Monroe City, Mo.	1940	1981	42	2230	7110007	988	743	715	1145	1508	2707	2908	2001	1971	1351	592	845	1454
05507600	Lick Creek At Perry Mo	1980	1993	14	104	7110007	14	99	103	41	90	90	86	97	53	103	27	67	72
05507800	Salt River Near Center Mo	1980	1993	14	2350	7110007	728	1529	2254	1190	1663	2715	2373	2266	2306	2350	1347	1363	1841
05508000	Salt River Near New London, Mo	1923	1993	71	2480	7110007	1037	1109	1158	1258	1862	2820	3061	2390	2401	1582	933	1076	1721

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05508800	Spencer Creek Nr Frankford Mo	1980	1980	1	200	7110007	39	1	0.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
05508805	Spencer Cr Below Plum Cr Nr Frankford Mo	1976	1993	18	206	7110007	59	196	224	89	197	286	243	261	94	191	64	120	169
05509700	Calumet Creek Near Clarksville, Mo	1965	1972	8	16	7110004	15	5	10	9	10	9	21	14	16	12	8	11	12
05513500	Lost Creek At Elsberry, Mo.	1955	1961	7	12	7110004	4	1	0.79	1	4	7	12	16	8	8	3	0.9	6
05514500	Culvre River Near Troy, Mo	1991	1993	2	903	7110008	9	984	842	1152	454	1382	1840	911	377	2991	661	4570	1349
05514500	Culvre River Near Troy, Mo	1922	1993	67	903	7110008	432	509	538	497	842	1020	1185	973	698	580	290	503	671
05514800	Dardenne Creek At Cottleville Mo	1979	1982	4	N/A	7110009	8	35	11	20	114	72	144	73	34	135	18	25	56
06812500	West Tarkio C N Westboro Mo	1934	1940	7	105	10240005	69	36	23	28	336	598	105	258	463	183	85	97	192
06813000	Tarkio River At Fairfax Mo	1922	1991	70	508	10240005	131	117	94	98	185	292	252	296	420	265	166	186	208
06816000	Mill Creek At Oregon Mo	1950	1976	27	5	10240005	2	1	1	1	2	2	2	4	4	3	2	2	2
06817500	Nodaway River Near Burlington Jct, Mo	1922	1984	63	1240	10240010	315	316	236	263	568	991	785	850	1148	523	349	455	566
06817700	Nodaway River Near Grahm	1987	1993	7	1380	10240010	529	585	711	450	575	1033	1260	1409	1451	2528	951	1404	1076
06818000	Missouri River At St. Joseph, Mo.	1929	1993	65	420300	10240011	38500	34800	22300	19700	26500	44500	57200	51800	64900	55600	41500	40600	41500
06818900	Platte R At Ravenwood Mo	1958	1971	14	486	10240012	131	148	68	152	337	511	344	399	436	234	119	261	261
06819500	One Hundred And Two River At Maryville Mo	1974	1975	2	515	10240013	N/A	N/A	17	12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7
06819500	One Hundred And Two River At Maryville Mo	1933	1991	59	515	10240013	149	118	82	102	234	419	336	410	478	219	134	168	237
06820000	White Cloud Creek Nr Maryville	1949	1970	22	6	10240013	2	1	0.55	2	3	4	4	5	7	5	2	3	3
06820500	Platte River Near Agency, Mo.	1925	1993	67	1760	10240012	661	542	379	389	821	1389	1465	1480	1950	1207	462	961	972
06821000	Jenkins Branch At Gower Mo	1950	1976	27	3	10240012	2	1	0.48	0.66	1	2	2	3	3	2	0.68	2	2
06821150	Little Platte River At Smithville, Mo.	1975	1975	1	234	10240012	89	175	22	39	122	N/A	N/A	N/A	15	3	3	71	57
06821150	Little Platte River At Smithville, Mo.	1965	1993	29	234	10240012	163	119	85	93	96	165	234	316	247	242	144	198	176
06821190	Platte River At Sharps Station, Mo	1979	1993	15	2380	10240012	1286	910	1288	669	1370	2407	2770	3129	2747	3548	1275	1817	1947
06821280	Line Creek At Riverside, Mo.	1976	1982	7	19	10240011	11	6	4	3	6	34	21	26	22	14	4	28	15
06893000	Missouri River At Kansas City Mo	1929	1993	65	485200	10300101	45800	41000	27100	23100	32200	53700	69400	65400	82600	70600	49400	49400	50900
06893500	Blue River Near Kansas City, Mo.	1939	1993	55	188	10300101	129	97	93	96	121	193	264	236	272	174	80	171	160
06893520	Blue River Nr Gregory Blvd At Kansas City, Mo	1981	1982	2	198	10300101	1210	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1292	N/A	N/A	1280
06893560	Brush Creek At Kansas City Mo	1971	1979	9	15	10300101	8	4	4	3	4	13	7	10	11	7	6	23	8
06893560	Brush Creek At Kansas City Mo	1974	1975	2	15	10300101	N/A	0.21	6	5	2	2	3	N/A	3	3	N/A	N/A	2
06893566	Blue River At Coal Mine Rd At Kansas City, Mo	1981	1982	2	230	10300101	576	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1131	N/A	N/A	854
06893600	Rock Creek At Independence Mo	1967	1978	10	5	10300101	6	2	2	2	2	5	5	7	7	3	2	7	4
06893670	Shoal Creek At Claycomo, Missouri	1975	1982	8	30	10300101	12	7	5	2	6	21	18	26	30	16	7	25	15
06893790	Little Blue R. At Longview Road In Kans. City, M	1966	1975	10	47	10300101	53	23	35	45	35	72	82	83	115	15	11	39	50

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06893793	L. Blue R. Bl Longview D.S. At Kansas City,Mo.	1975	1993	19	50	10300101	35	29	23	18	30	45	51	70	60	29	17	37	37
06893880	Jackson County Lake Near Blue Springs, Mo.	1974	1983	10	26	10300101	12	14	8	20	27	38	57	59	74	14	17	14	30
06893880	Jackson County Lake Near Blue Springs, Mo.	1974	1974	1	26	10300101	N/A	N/A	34	44	0.23	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28
06893890	East Fork Little Blue River Nr Blue Springs, Mo.	1975	1993	19	34	10300101	24	16	17	13	16	33	47	52	44	21	22	25	28
06894000	Little Blue River Near Lake City, Mo	1948	1993	46	184	10300101	135	101	88	92	121	199	231	240	263	144	94	161	156
06894500	E.F. Fishing R. At Excelsior Springs, Mo.	1951	1973	23	20	10300101	10	9	4	5	10	16	22	17	21	26	7	14	13
06894680	Sniabar Creek Near Tarsney Mo	1970	1982	11	29	10300101	13	14	45	17	21	47	37	36	13	14	0.77	44	25
06895000	Crooked River Near Richmond, Mo.	1948	1970	23	159	10300101	55	58	20	46	96	124	149	119	184	179	45	103	99
06895500	Missouri River At Waverly Mo	1929	1993	65	487200	10300101	45900	41100	27900	23700	32800	53800	71800	66700	83800	72800	49700	49000	51600
06896000	Wakenda Creek At Carrollton, Mo.	1948	1970	23	248	10300101	142	83	35	69	140	175	168	153	244	223	135	141	143
06896500	Thompson Branch Near Albany Mo	1956	1972	17	6	10280101	3	2	0.54	1	3	4	3	5	4	3	0.58	6	3
06897000	East Fork Big Creek Near Bethany Mo	1934	1972	39	95	10280101	25	25	14	24	60	83	69	74	114	32	17	37	48
06897500	Grand River Near Gallatin Mo	1921	1993	73	2250	10280101	823	871	539	506	949	1742	1914	1736	2318	1668	555	1140	1228
06898100	Thompson River At Mount Moriah Mo	1960	1977	18	891	10280102	337	361	207	271	539	984	912	726	745	405	143	574	516
06898500	Weldon River Near Mercer, Mo.	1940	1959	20	246	10280102	54	38	38	66	138	204	220	262	405	95	101	43	138
06899000	Weldon River At Mill Grove Mo	1929	1972	44	494	10280102	137	162	94	136	252	394	399	379	527	163	164	173	248
06899500	Thompson River At Trenton Mo	1929	1993	65	1670	10280102	603	685	496	478	903	1619	1700	1584	1791	1109	548	755	1021
06899700	Shoal Creek Near Braymer Mo	1958	1978	21	391	10280102	155	182	85	167	247	349	394	380	377	223	93	274	243
06900000	Medicine Creek Near Galt, Mo	1922	1991	68	225	10280103	102	96	70	71	143	241	252	201	265	135	71	99	145
06901000	Locust Creek Near Milan, Mo.	1922	1933	12	225	10280103	171	236	90	77	124	189	283	70	226	102	121	148	153
06901500	Locust Creek Near Linneus, Mo	1929	1972	44	550	10280103	169	207	146	190	304	476	589	458	692	284	137	169	318
06902000	Grand River Near Sumner Mo	1925	1993	68	6880	10280103	2725	2977	2080	1906	3529	5850	6649	5486	7369	4792	1809	3218	4025
06902200	West Yellow Creek Near Brookfield Mo	1959	1977	19	135	10280103	64	46	38	87	83	172	220	182	115	81	26	95	100
06902500	Hamilton Branch Near New Boston Mo	1956	1972	17	3	10280103	2	1	1	1	2	3	4	3	3	3	0.61	2	2
06903000	Yellow Creek Near Rothville, Mo.	1929	1951	7	405	10280103	118	313	117	256	340	211	505	180	732	178	46	77	262
06904050	Chariton River At Livonia, Mo.	1974	1993	20	864	10280201	439	500	676	389	563	919	914	815	821	1112	661	601	704
06904500	Chariton River At Novinger Mo	1931	1993	61	1370	10280202	514	585	557	524	802	1459	1430	1240	1448	954	550	556	884
06905000	Chariton River At Elmer, Mo.	1922	1930	9	1660	10280202	1385	1209	577	323	1157	1477	2263	606	1748	770	329	1364	1106
06905500	Chariton River Near Prairie Hill, Mo.	1929	1993	65	1870	10280202	734	832	763	742	1114	1945	2106	1862	2018	1449	709	769	1254
06906000	Mussel Fork Near Musselfork, Missouri	1949	1990	32	267	10280202	163	158	169	143	243	318	463	335	315	245	71	156	230
06906200	East Fork Little Chariton R Nr Macon Mo	1971	1993	23	112	10280203	67	73	100	67	62	150	189	173	97	104	69	82	103
06906300	East Fork Little Chariton R Nr Huntsville Mo	1963	1993	31	220	10280203	129	132	137	131	150	266	335	253	211	209	84	150	182

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0690633910	Twenty-Five Mine Discharge Near Keota Mo	1984	1984	1	N/A	10280203	0.54	0.67	0.66	N/A	N/A	0.9	0.91	0.8	0.64	N/A	N/A	N/A	0.74
0690634025	Stinking Creek Near Calleo Mo	1984	1984	1	N/A	10280203	N/A	N/A	N/A	N/A	N/A	10	14	N/A	N/A	N/A	N/A	N/A	13
06906470	Middle Fork Little Chariton R Bl Salisbury, Mo.	1965	1970	6	201	10280203	126	73	50	150	118	165	382	256	348	354	47	153	185
06906600	Burge Branch Near Arrow Rock Mo	1960	1973	14	0.331	10300102	0.15	0.07	0.05	0.09	0.12	0.24	0.36	0.21	0.19	0.13	0.03	0.2	0.15
06906700	Flat C Nr Sedalia, Mo.	1961	1967	7	148	10300103	48	51	25	29	36	123	154	123	161	88	55	159	88
06906800	Lamine River Near Otterville, Missouri	1988	1993	6	543	10300103	15	624	533	283	341	617	730	1110	332	825	126	647	516
06907000	Lamine River At Clifton City, Mo.	1922	1971	50	598	10300103	336	292	261	336	423	565	759	772	884	350	161	315	453
06907500	South Fork Blackwater River Near Elm, Mo.	1954	1980	27	17	10300104	10	5	5	7	9	17	23	17	15	12	4	13	11
06907700	Blackwater River At Valley City Mo	1959	1973	15	547	10300104	300	210	178	274	269	594	984	599	782	557	125	549	451
06908000	Blackwater River At Blue Lick, Missouri	1922	1993	68	1120	10300104	559	600	454	468	669	1052	1374	1086	1211	830	284	614	765
06908500	Shiloh Branch Near Marshall, Mo.	1952	1965	14	3	10300104	0.95	0.7	0.66	0.53	1	2	2	2	1	2	0.76	2	1
06909000	Missouri River At Boonville, Mo.	1926	1993	68	501700	10300102	52900	48800	33700	28900	41300	66100	88000	80500	99300	83900	55700	56800	61300
06909500	Moniteau Creek Near Fayette, Mo.	1948	1969	22	81	10300102	21	21	19	32	51	62	63	44	52	53	12	14	37
06910000	Petite Saline Creek Near Boonville, Mo.	1948	1967	20	182	10300102	65	45	28	64	103	144	140	137	168	125	71	96	99
06910230	Hinkson Creek At Columbia, Mo.	1967	1991	20	70	10300102	30	23	31	38	51	89	80	99	76	52	18	20	50
06910410	Cedar Creek Near Columbia Mo	1964	1991	18	45	10300102	32	13	29	35	34	62	58	64	50	28	16	22	36
06910500	Moreau River Near Jefferson City, Mo	1948	1975	27	561	10300102	311	224	221	359	422	652	534	542	611	333	119	289	385
06916654	Unnamed Trib To Mulberry Ck Nr Amoret, Mo	1982	1982	1	N/A	10290102	N/A	216	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	216
06916655	Mulberry Creek Nr Amoret,Mo	1982	1982	1	N/A	10290102	N/A	720	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	720
06918070	Osage River Above Schell City, Mo.	1980	1993	14	5410	10290105	6737	5183	4414	2688	4817	7924	6729	6272	7708	5907	2530	2175	5378
06918440	Sac River Near Dadeville, Mo	1966	1993	28	257	10290106	127	292	336	247	293	452	386	302	212	119	65	125	244
06918444	Chesapeake Spring At Chesapeake Mo	1966	1967	2	0	10290106	2	1	2	2	3	3	3	3	3	3	2	2	2
06918460	Turnback Creek Above Greenfield, Mo	1965	1993	29	252	10290106	139	314	327	256	321	480	426	336	254	156	96	150	270
06918700	Oak Grove Br Nr Brighton, Mo	1956	1975	20	1	10290106	0.44	1	1	0.68	1	2	2	1	0.49	0.65	0.05	0.4	0.97
06918740	Little Sac River Near Morrisville, Mo	1968	1993	26	237	10290106	126	329	325	241	283	488	396	285	195	80	37	220	250
06918800	Little Sac River At Aldrich, Mo.	1967	1968	2	304	10290106	356	354	922	386	623	613	257	205	146	45	37	27	286
06919000	Sac River Near Stockton, Mo	1921	1990	70	1160	10290106	552	646	763	904	986	1263	1793	1673	1414	840	619	589	1001
06919020	Sac River At Highway J Below Stockton Mo	1974	1993	20	1292	10290106	554	647	1210	1375	1220	1598	1928	1647	1371	1057	850	949	1200
06919500	Cedar Creek Near Pleasant View, Mo	1923	1993	49	420	10290106	179	338	304	265	394	584	512	455	353	253	86	197	325
06919900	Sac River Near Caplinger Mills, Mo.	1975	1993	19	1810	10290106	954	1260	1788	1655	1817	2401	2515	2222	1782	1291	937	1220	1652
06920500	Osage River At Osceola, Mo	1917	1978	60	8220	10290105	3919	3928	2809	3459	4143	6687	9366	8193	8480	4989	2641	3609	5194
06921000	Pomme De Terre River Near Bolivar, Mo.	1951	1969	19	225	10290107	95	110	148	121	223	286	299	290	171	181	35	79	170

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06921070	Pomme De Terre River Near Polk, Mo	1969	1993	25	276	10290107	156	363	381	273	336	563	493	331	218	80	42	184	284
06921200	Lindley Creek Near Polk, Mo	1957	1991	35	112	10290107	85	92	120	94	127	205	170	144	79	34	14	33	99
06921325	Pomme De Terre Lake Near Hermitage Mo	1973	1973	1	611	10290107	231600	271900	250300	257000	256000	329800	441600	387100	255700	238700	234000	232700	267200
06921350	Pomme De Terre River Near Hermitage, Mo.	1960	1993	34	615	10290107	241	510	716	544	590	871	877	842	513	310	105	138	520
06921500	Pomme De Terre River At Hermitage, Mo.	1922	1965	44	655	10290107	370	369	382	476	561	867	1083	1044	850	400	357	287	587
06921590	South Grand River At Archie, Mo	1970	1986	17	256	10290108	217	266	211	198	269	478	459	457	542	116	98	312	301
06921600	South Grand River At Urich, Mo.	1961	1969	9	670	10290108	232	381	236	256	297	475	700	652	1105	207	121	690	444
06921720	Big Creek Near Blairstown, Mo	1960	1975	16	414	10290108	293	215	220	278	207	431	557	408	579	167	95	351	315
06921740	Brushy Creek Near Blairstown Mo	1961	1975	15	1	10290108	0.89	0.9	0.93	1	0.93	2	2	2	1	0.52	0.59	1	1
06921760	South Grand River Near Clinton, Mo	1985	1993	9	1270	10290108	1862	1203	1315	638	565	1401	1663	1899	767	1727	550	803	1195
06922000	South Grand River Near Brownington, Mo.	1921	1971	51	1660	10290108	750	691	445	620	799	1265	2025	1677	2071	1005	490	856	1055
06922450	Osage R. Bl Harry S. Truman Dam At Warsaw, Mo	1982	1993	10	7856	10290109	8595	11200	16300	10900	10400	16000	17300	15700	12800	6362	5995	4382	11300
06922500	Osage River At Warsaw, Mo.	1926	1931	6	11500	10290109	9748	7962	5700	5779	7955	8159	21500	16100	15400	4280	9006	3904	9599
06922800	Big Buffalo Creek Near Stover,Mo.	1965	1977	13	24	10290109	20	16	18	18	18	29	39	34	25	13	6	19	21
06923000	Niangua Branch At Marshfield Mo	1950	1957	8	1	10290110	0.43	0.7	0.32	0.18	0.79	0.79	1	1	0.7	0.38	0.19	0.11	0.56
06923150	Dousinbury Cr On Jj Near Wall Street, Mo	1993	1993	1	36	10290110	N/A	N/A	N/A	N/A	N/A	N/A	37	36	52	7	3	305	74
06923250	Niangua River At Windyville, Missouri	1991	1993	3	377	10290110	35	563	536	370	306	349	328	313	378	108	53	948	363
06923500	Bennett Spring At Bennett Springs Mo	1929	1993	40	100	10290110	132	153	170	166	185	223	247	240	191	144	126	127	175
06924000	Niangua River Near Decaturville, Mo.	1930	1969	40	627	10290110	423	451	462	541	647	873	1022	1078	849	455	350	393	629
06924500	Hahatonka Sp At Hahatonka Mo	1923	1926	4	0	10290110	64	71	74	66	69	77	84	74	88	72	73	79	74
06925000	Niangua R Nr Roach Mo	1923	1930	8	698	10290110	658	745	830	701	706	1026	1574	1395	1618	535	913	527	940
06925200	Starks Creek At Preston Mo	1956	1977	22	4	10290110	3	3	4	4	4	8	6	6	3	1	0.44	2	4
06926000	Osage River Near Bagnell, Missouri	1925	1993	69	14000	10290111	7283	8266	8081	8192	9934	13500	16900	15400	14400	8822	5302	5919	10100
06926200	Van Cleve Branch Near Meta Mo	1956	1972	17	1	10290111	0.37	0.2	0.44	0.3	0.41	0.77	1	1	0.58	0.3	0.06	0.36	0.49
06926500	Osage River Near St. Thomas, Missouri	1931	1993	63	14500	10290111	7012	8532	8491	8648	10500	14500	16800	16000	15200	10000	5246	6354	10600
06926500	Osage River Near St. Thomas, Missouri	1979	1980	2	14500	10290111	693	2711	2830	N/A	N/A	N/A	N/A	N/A	N/A	8709	2621	2876	2947
06927000	Maries River At Westphalia, Mo.	1948	1971	24	257	10290111	122	81	133	191	245	361	356	402	352	145	55	101	213
06927200	Big Hollow Near Fulton Mo	1957	1972	16	4	10300102	2	1	1	2	3	4	6	4	4	2	0.67	4	3
06927800	Osage Fork Gasconade River At Drynob, Mo.	1962	1982	21	404	10290201	130	273	283	281	358	515	489	449	265	133	71	143	280
06928000	Gasconade River Near Hazlegreen, Missouri	1929	1972	44	1250	10290201	511	667	713	965	1164	1580	1778	1856	1139	556	294	372	964
06928200	Laquey Branch Near Hazlegreen Mo	1958	1972	15	2	10290201	0.79	0.71	2	1	1	2	3	3	0.86	0.64	0.16	0.75	1
06928500	Gasconade River Near Waynesville, Missouri	1915	1972	58	1680	10290201	749	977	1049	1323	1580	2113	2600	2521	1793	754	684	600	1392

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06928700	Beeler Branch Near Cabool Mo	1968	1977	10	8	10290202	3	10	11	9	7	12	16	7	4	0.87	1	3	7
06929315	Paddy Creek Above Slabtown Spring, Mo	1993	1993	1	34	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	1	1	139	43
06930000	Big Piney River Nr Big Piney, Mo	1922	1993	67	560	10290202	267	454	453	558	637	839	976	906	624	305	244	258	542
06931000	Beaver Creek Near Rolla, Mo.	1948	1955	8	14	10290203	15	7	8	20	21	25	15	16	17	8	3	4	13
06931500	Little Beaver Cr Nr Rolla, Mo	1948	1975	28	6	10290203	3	4	4	6	7	10	9	9	6	3	2	2	5
06932000	Little Piney Creek At Newburg, Mo	1929	1993	65	200	10290203	98	131	153	148	175	225	250	258	206	100	82	88	159
06933000	Wilkins Spring Near Newburg, Mo.	1953	1959	7	0	10290203	6	5	6	6	6	8	8	8	7	7	6	6	6
06933500	Gasconade River At Jerome Mo	1903	1993	75	2840	10290203	1404	2235	2529	2420	2951	3936	4597	4231	3103	1583	1207	1314	2630
06934000	Gasconade River Near Rich Fountain, Mo.	1922	1993	45	3180	10290203	1707	2274	2535	2866	3187	4437	5503	5061	3937	1858	1416	1492	3021
06934500	Missouri River At Hermann, Mo	1929	1993	65	524200	10300200	63700	63700	48900	43400	57600	89700	115000	108400	120400	99100	64700	66200	78400
06935000	Rumbo Branch At Danville, Mo.	1953	1958	6	1	10300200	0.23	0.01	0.01	0.25	0.69	0.77	1	1	1	2	0.11	0.63	0.85
06935500	Loutre River At Mineola, Mo.	1948	1967	20	202	10300200	64	30	26	82	123	205	204	130	122	112	18	62	98
06936500	Coldwater Cr At Hwy 67, Nr St Louis, Mo	1961	1965	4	44	10300200	28	32	30	25	32	66	53	87	52	39	32	29	42
07005000	Maline Cr At Bellefontaine, Bellefontaine Nbr,Mo	1979	1981	3	N/A	7140101	29	24	23	33	77	177	871	47	38	41	50	23	153
07010000	Mississippi River At St Louis Mo	1933	1993	61	97000	7140101	135900	140000	121600	114300	141300	230400	305400	280300	259600	218000	142300	138300	186000
07010016	River Des Peres At Hafner Pl, University City,Mo	1979	1981	3	6	7140101	3	2	1	0.93	8	5	13	4	4	5	2	6	5
07010044	Deer Cr At Warson Rd, In Ladue, Mo	1970	1981	5	N/A	7140101	5	8	5	4	15	11	10	18	15	16	10	4	10
07010086	Deer Cr At Big Bend, In Maplewood, Mo	1979	1982	4	37	7140101	49	73	30	10	43	47	104	71	69	93	44	26	53
07010155	Gravois Cr At Tesson Ferry Rd, Sappington, Mo	1979	1982	4	N/A	7140102	4	7	2	3	12	8	15	2	6	13	9	2	7
07010350	Meramec River At Cook Station, Mo	1966	1982	17	199	7140102	36	100	113	135	148	207	221	163	63	34	27	32	106
07010500	Maramec Spring Near St. James	1922	1986	29	0	7140102	109	140	160	138	164	183	219	196	170	128	117	107	152
07011500	Green Acre Branch Near Rolla Mo	1948	1975	28	1	7140102	0.2	0.23	0.35	0.48	0.58	0.77	0.49	0.68	0.41	0.23	0.13	0.13	0.39
07012000	Behmke Branch Near Rolla Mo	1948	1959	12	1	7140102	0.69	0.33	0.49	0.97	1	2	1	2	0.99	0.79	0.35	0.24	0.89
07013000	Meramec River Near Steelville, Mo	1923	1993	71	781	7140102	286	466	587	566	652	870	1041	951	735	348	265	287	587
07014500	Meramec River Near Sullivan, Mo.	1922	1993	62	1475	7140102	590	984	1260	1215	1425	1905	2313	1931	1316	724	536	556	1227
07015000	Bourbeuse River Nr St. James Mo	1948	1982	35	21	7140103	9	10	14	17	22	33	26	30	15	9	3	5	16
07015500	Lanes Fk Nr Rolla, Mo	1952	1971	20	0.221	7140103	0.07	0.08	0.22	0.16	0.27	0.38	0.31	0.44	0.2	0.11	0.05	0.1	0.2
07015720	Bourbeuse River Nr High Gate Mo	1965	1993	29	135	7140103	50	156	214	136	179	230	232	165	103	39	34	57	132
07016000	Bourbeuse River Near Spring Bluff Mo	1966	1982	17	608	7140103	3198	3541	2905	3616	4047	3386	4421	4594	4031	3260	2173	3487	3740
07016500	Bourbeuse River At Union, Mo	1921	1993	73	808	7140103	317	506	675	625	771	1121	1237	1100	843	347	192	269	664
07017000	Meramec River At Robertsville, Mo.	1940	1951	12	2673	7140102	1613	1600	1613	2747	2778	3590	4705	4014	4015	2037	1046	1118	2568
07017200	Big River At Irondale, Mo	1965	1993	29	175	7140104	66	222	298	210	256	325	342	211	112	52	62	71	184

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07017500	Dry Branch Near Bonne Terre, Missouri	1956	1976	21	3	7140104	0.41	2	3	3	4	6	6	5	2	0.79	0.49	0.84	3
07018000	Big River Near Desoto, Missouri	1949	1983	35	718	7140104	252	448	741	675	860	1210	1254	996	469	436	254	261	651
07018100	Big River Near Richwoods Mo	1983	1993	11	735	7140104	370	1232	1309	874	1136	1281	1157	987	731	312	308	597	855
07018500	Big River At Byrnesville	1922	1993	72	917	7140104	336	668	904	916	1103	1440	1627	1376	806	502	297	368	859
07019000	Meramec River Near Eureka, Mo	1974	1974	1	3788	7140102	995	5377	7350	8189	7654	8432	6736	4876	N/A	N/A	N/A	N/A	6584
07019000	Meramec River Near Eureka, Mo	1904	1993	75	3788	7140102	1434	2376	3070	3154	3840	5161	6146	5090	3570	1930	1178	1487	3202
07019570	Joachim Creek At Hematite, Mo.	1971	1971	1	95	7140101	19	18	16	21	62	N/A	25	56	N/A	N/A	N/A	N/A	28
07019690	Sandy Creek Near Pevely, Mo.	1966	1973	7	33	7140101	8	11	25	13	21	26	58	32	7	3	30	18	21
07019790	Plattin Creek At Plattin, Mo.	1966	1973	8	66	7140101	11	52	71	55	64	63	122	71	23	25	15	14	49
07020270	Saline Creek Near Minnith Mo	1980	1982	3	83	7140105	9	12	20	11	30	18	16	141	98	28	11	8	28
07020860	Cape La Croix At Highway 61 In Cape Girardeau Mo	1979	1982	4	12	7140105	0.73	14	13	24	23	33	25	21	7	10	3	0.73	15
07020870	Cape La Croix At Bloomfield Rd In Cape Girardeau	1979	1982	4	12	7140105	4	35	56	55	57	72	112	57	8	26	9	3	41
07021000	Castor River At Zalma, Mo	1920	1991	72	423	7140107	161	397	588	725	708	1034	1028	787	432	167	106	118	520
07033800	Brewers C Nr Ironton, Mo.	1965	1966	2	2	8020202	0	N/A	0.26	1	3	1	7	3	0.05	N/A	0.11	0.5	1
07034000	St. Francis River Near Roselle, Mo	1987	1993	7	234	8020202	46	242	460	340	367	406	414	347	99	41	39	125	243
07035000	Little St. Francis River At Fredericktown, Mo.	1939	1993	12	91	8020202	41	198	183	134	163	212	171	172	86	19	35	28	119
07035500	Barnes Creek Near Fredericktown, Missouri	1956	1976	21	4	8020202	1	5	6	5	6	9	11	8	3	1	2	2	5
07035800	St. Francis River Near Mill Creek, Mo	1988	1993	6	505	8020202	74	616	1074	994	895	934	1005	866	247	79	74	223	589
07036100	St. Francis River Near Saco,Mo.	1983	1993	11	664	8020202	355	1710	1573	1151	1338	1588	1390	1213	692	102	176	201	935
07037000	Big Creek At Des Arc, Mo.	1987	1993	7	100	8020202	41	173	244	222	160	209	262	164	83	38	24	41	138
07037500	St. Francis River Near Patterson, Mo	1921	1993	73	956	8020202	366	958	1326	1468	1554	2163	2314	1708	923	330	219	256	1126
07037700	Clark Creek Near Piedmont Mo	1957	1976	20	4	8020202	0.82	4	4	5	5	9	10	7	2	2	0.99	2	4
07039500	St. Francis River At Wappapello, Mo.	1941	1993	53	1311	8020202	394	899	1913	2384	2290	2715	2902	2461	1357	730	393	408	1567
07040000	St. Francis River At Fisk, Mo	1928	1941	14	1370	8020203	371	645	1228	2552	1695	2163	2598	1965	1436	522	293	260	1309
07041000	Little River Ditch 81 Near Kennett Mo	1927	1979	53	111	8020204	74	134	185	313	300	320	332	261	214	135	82	72	201
07042000	Little River Ditch 1 Near Kennett Mo	1927	1979	53	235	8020204	104	238	376	772	719	758	758	558	380	188	113	102	421
07042500	Little River Ditch 251 Near Lilbourn, Mo.	1946	1991	46	235	8020204	138	257	386	461	542	537	467	461	292	207	138	122	333
07043000	Castor River At Aquilla, Mo	1946	1982	37	175	8020204	32	111	175	281	284	372	301	240	102	69	38	46	171
07043500	Little River Ditch No 1 Near Morehouse, Mo.	1946	1991	46	450	8020204	177	427	657	772	898	961	878	741	383	267	180	178	541
07044000	Little River Ditch 251 Near Kennett Mo	1927	1979	53	883	8020204	251	448	637	1058	1042	1203	1177	921	678	401	276	243	693
07045000	Little River Ditch 66 Near Kennett Mo	1927	1979	53	N/A	8020204	119	258	413	636	628	723	772	552	363	208	134	126	410
07045500	Little River Ditch 66A Near Kennett, Mo.	1927	1965	39	N/A	8020204	4	22	18	123	74	90	101	66	59	10	2	0.88	48

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07046000	Little River Ditch 259 Near Kennett Mo	1927	1979	53	89	8020204	29	78	121	230	208	217	212	153	95	48	28	22	120
07050150	Roaring River Spring Near Cassville Mo	1966	1968	3	0	11010001	19	23	32	33	45	45	45	37	29	27	28	25	32
07050580	James River Near Strafford, Mo.	1974	1986	13	165	11010002	61	219	266	129	208	332	298	185	176	60	31	81	170
07050700	James River Near Springfield, Mo.	1956	1993	38	246	11010002	106	246	317	214	264	423	408	385	204	117	41	127	237
07052000	Wilson Creek At Scenic Drive In Springfield, Mo.	1933	1977	12	18	11010002	14	18	14	23	22	27	26	31	41	14	11	49	24
07052050	N. F. Wilson Ck At Hwy 13 And 160,Springfield,Mo	1973	1977	5	5	11010002	6	6	6	6	6	10	6	659	8	7	6	9	57
07052100	Wilsons Creek Nr Springfield Mo	1972	1982	11	31	11000002	19	28	14	13	16	39	33	36	34	16	11	17	23
07052150	Wilson Creek Below Springfield, Mo.	1967	1972	6	47	11000002	48	47	64	37	38	45	41	39	30	23	20	37	38
07052160	Wilsons Creek Nr Battlefield Mo	1968	1982	14	55	11010002	61	115	80	78	89	150	123	109	99	63	50	61	90
07052250	James River Near Boaz, Mo.	1972	1981	10	462	11010002	234	780	445	398	548	1253	930	731	466	324	147	307	545
07052500	James River At Galena, Mo	1922	1993	72	987	11010002	497	837	979	897	1099	1505	1748	1583	1196	602	406	440	981
07053000	White River Near Reeds Spring, Mo.	1938	1952	15	3617	11010003	1699	3658	3046	4037	6425	6536	8857	9232	4476	2203	1363	1029	4382
07053500	White River Near Branson, Mo.	1952	1992	41	4022	11010003	1613	2795	3860	3517	3947	5330	5983	5898	4014	3248	2711	1999	3742
07057350	Tributary To Middle Indian Creek Near Cabool, Mo	1987	1987	1	1	11010006	1	22	0.16	0.21	2	1	0.97	0.05	0	0.04	N/A	N/A	3
07057360	Middle Indian Creek Near Cabool, Mo.	1987	1987	1	5	11010006	3	0.23	0.2	0.19	6	3	3	0.12	0.26	0.12	0.1	N/A	1
07057500	North Fork River Near Tecumseh, Mo	1945	1993	49	561	11010006	404	623	720	735	852	1055	1250	1124	776	551	415	428	743
07057800	Hodgson Mill Spring At Sycamore, Mo.	1966	1968	3	0	11010006	38	37	41	41	43	41	45	43	41	42	39	38	41
07058000	Bryant Creek Near Tecumseh, Mo	1945	1985	41	570	11010006	240	421	541	510	631	841	969	869	526	362	234	227	530
07058500	North Fork River At Tecumseh	1922	1944	23	1157	11010006	796	985	1074	1201	1329	1439	1944	1862	1593	790	703	635	1194
07061300	East Fork Black River At Lesterville, Mo	1960	1991	32	95	11010007	34	165	196	108	166	236	234	154	72	19	29	34	120
07061500	Black River Near Near Annapolis, Mo	1939	1993	55	484	11010007	266	615	696	610	730	995	1152	861	516	269	208	230	594
07062500	Black River At Leeper, Mo	1921	1993	73	987	11010007	470	681	1009	1155	1211	1492	1694	1460	1091	558	464	445	974
07063000	Black River At Poplar Bluff, Mo	1937	1993	55	1245	11010007	630	967	1407	1650	1690	2060	2268	1977	1297	790	641	604	1330
07064300	Fudge Hollow Nr Licking, Mo	1957	1976	20	2	11010008	0.1	0.3	0.19	0.21	0.18	0.24	0.33	0.48	0.19	0.15	0.08	0.19	0.22
07064500	Big Creek Near Yukon, Mo	1949	1976	28	8	11010008	4	8	9	9	10	16	20	12	4	4	1	3	8
07065000	Round Spring At Round Spring Mo	1929	1980	26	0	11010008	25	35	42	49	53	68	81	73	48	36	28	27	47
07065495	Jacks Fork River At Alley Spring, Mo	1993	1993	1	298	0	N/A	N/A	N/A	N/A	N/A	438	549	233	133	103	78	1007	351
07065500	Alley Spring At Alley Mo	1929	1980	27	0	11010008	92	108	122	138	148	175	200	183	141	114	97	93	134
07066000	Jacks Fork At Eminence, Mo	1922	1993	72	398	11010008	222	395	457	477	550	702	838	726	467	257	206	206	458
07066500	Current River Near Eminence, Mo	1921	1976	56	1272	11010008	803	1160	1235	1477	1632	2053	2563	2332	1672	975	809	751	1451
07066550	Blue Spring Near Eminence, Mo.	1970	1971	2	0	11010008	136	129	92	145	159	131	101	112	88	75	74	83	105
07067000	Current River At Van Buren, Mo	1921	1993	73	1667	11010008	1072	1655	1924	2014	2218	2780	3397	3023	2113	1312	1089	1026	1963

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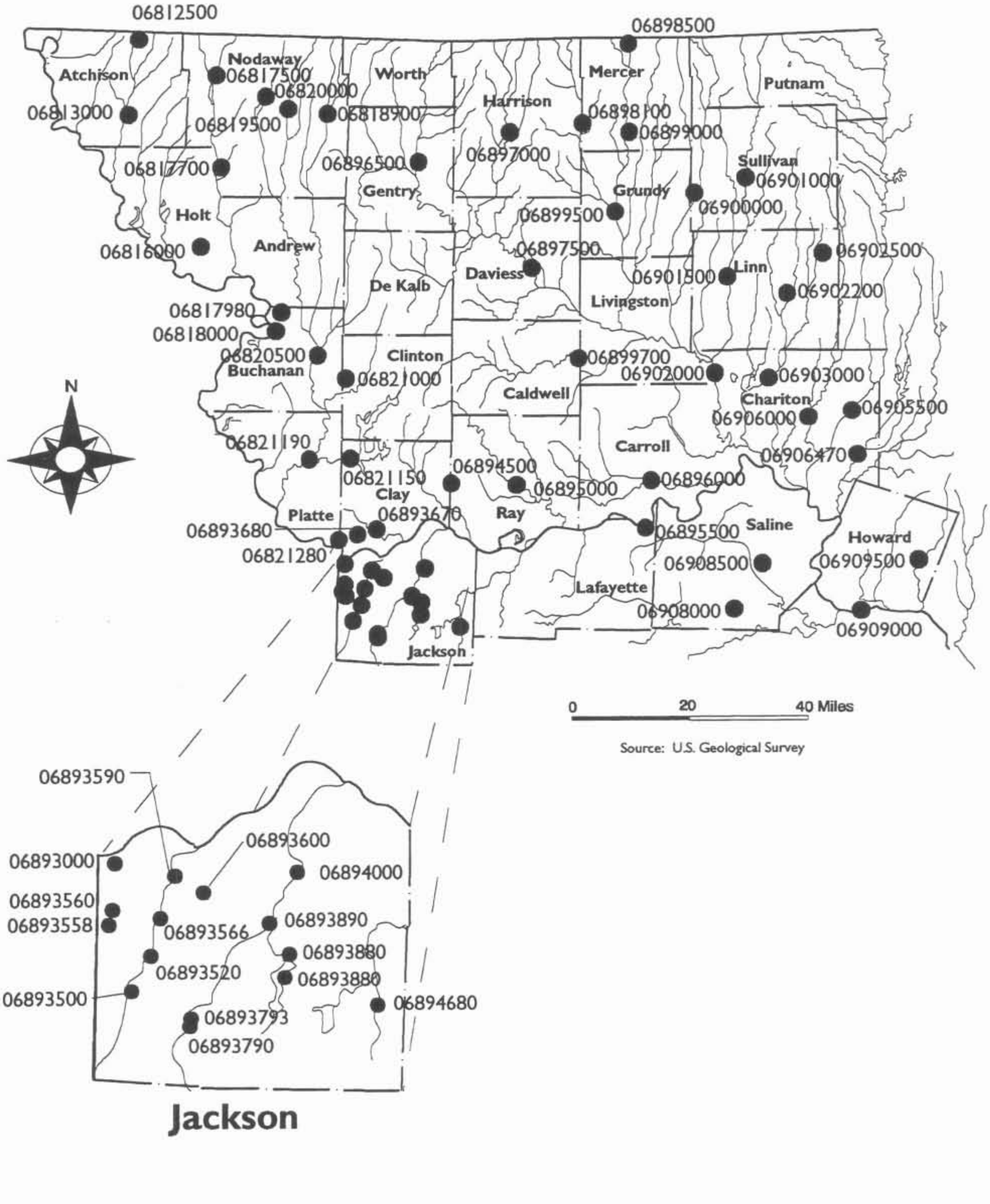
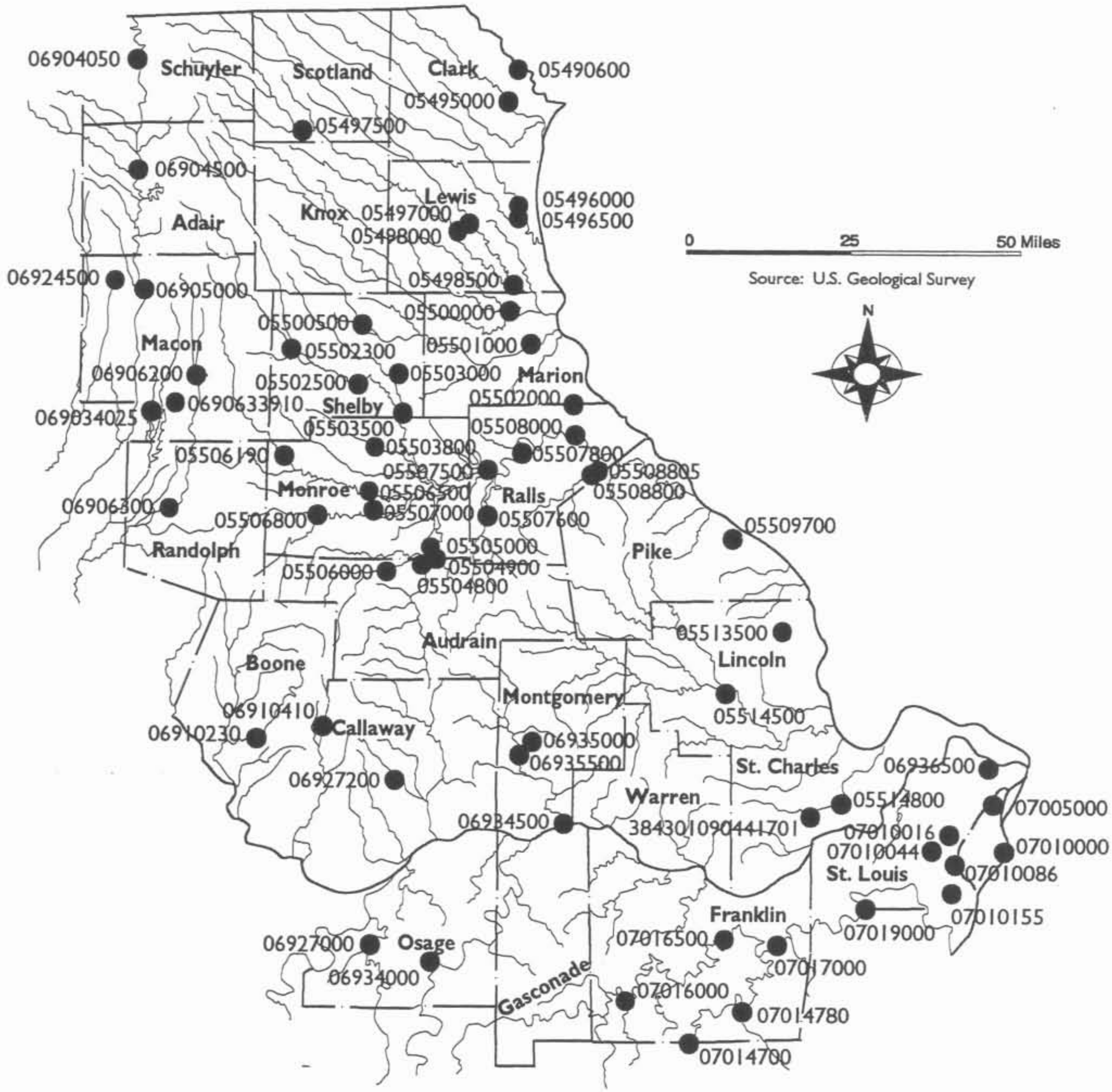
07067500	Big Spring Near Van Buren Mo	1922	1993	72	100	11010008	343	384	413	441	463	521	577	559	483	412	375	349	443
07068000	Current River At Doniphan,Mo.	1921	1993	73	2038	11010008	1621	2313	2719	2893	3087	3810	4605	4102	2972	1968	1677	1578	2772
07068250	Middle Fork L Black R At Grandin Mo	1981	1984	4	7	11010008	0.33	8	29	13	4	9	10	10	1	0.15	6	3	8
07068300	North Prong L Black R Nr Grandin Mo	1980	1984	5	39	11010008	7	42	141	60	35	43	50	39	10	6	20	7	37
07068380	Little Black River Nr Grandin Mo	1980	1984	5	80	11010008	25	87	275	131	84	87	120	109	31	14	61	16	83
07068510	Little Black River Below Fairdealing,Mo.	1980	1986	7	194	11010008	105	313	559	252	302	332	372	299	118	56	94	48	229
07068540	Logan Creek At Oxly Mo	1980	1984	5	38	11010008	5	37	109	62	45	43	64	50	13	6	20	4	37
07068863	Fourche River Near Poynor, Mo.	1976	1984	9	87	11010009	21	70	225	86	126	252	194	111	72	38	32	19	103
07070000	Kings Creek Near Willow Springs Mo	1955	1967	13	5	11010011	0.17	0.24	0.22	0.35	0.61	0.83	1	2	0.31	0.48	0.08	0.05	0.6
07070500	Eleven Point River Near Thomasville, Mo	1951	1977	27	361	11010011	26	85	90	88	113	164	243	193	93	57	29	25	100
07071000	Greer Spring At Greer Mo	1922	1993	71	100	11010011	255	280	304	330	345	391	445	445	403	335	295	267	341
07071500	Eleven Point River Near Bardley, Mo	1922	1993	72	793	11010011	417	566	716	802	840	1058	1318	1155	897	611	487	431	774
07185500	Stahl Creek Near Miller Mo	1950	1977	28	4	11070207	3	4	2	2	3	5	4	4	4	2	0.58	1	3
07185700	Spring River At Larussell, Mo.	1957	1982	26	306	11070207	163	271	212	184	226	385	368	393	358	205	113	142	251
07185765	Spring River At Carthage, Mo	1967	1981	15	425	11070207	225	501	389	331	429	701	545	483	436	273	136	230	389
07186000	Spring River Near Waco, Mo	1924	1993	70	1164	11070207	652	901	727	705	914	1217	1415	1474	1389	710	457	599	929
07186400	Center Creek Near Carterville, Mo	1962	1991	30	232	11070207	113	258	223	181	218	354	333	272	230	122	63	104	205
07186500	Turkey Creek At Joplin, Mo	1933	1939	7	33	11070207	17	11	13	18	11	17	19	28	34	8	5	9	16
07186600	Turkey Creek Near Joplin, Mo	1964	1973	10	42	11070207	34	40	30	30	33	40	60	47	56	27	23	37	38
07187000	Shoal Creek Above Joplin, Missouri	1942	1993	52	427	11070207	286	394	360	322	381	552	652	701	555	352	221	260	419
07187500	Shoal C Nr Joplin Mo	1924	1941	18	458	11070207	265	228	280	319	331	339	695	575	754	321	357	307	400
07188500	Lost Creek At Seneca, Mo	1949	1959	11	42	11070206	15	14	10	16	28	36	41	57	46	34	21	19	28
07189000	Elk River Near Tiff City, Mo	1940	1994	55	872	11070208	437	727	787	679	868	1346	1665	1551	947	487	273	303	841
384301090441701	Estavelle At Busch Wildlife At Weldon Spring, Mo	1987	1987	1	0	0	0.42	0.14	0.33	0.37	0.23	0.56	0.32	N/A	N/A	0.14	0.01	N/A	0.24

APPENDIX 6
STREAM GAGE LOCATIONS
Northwestern Missouri

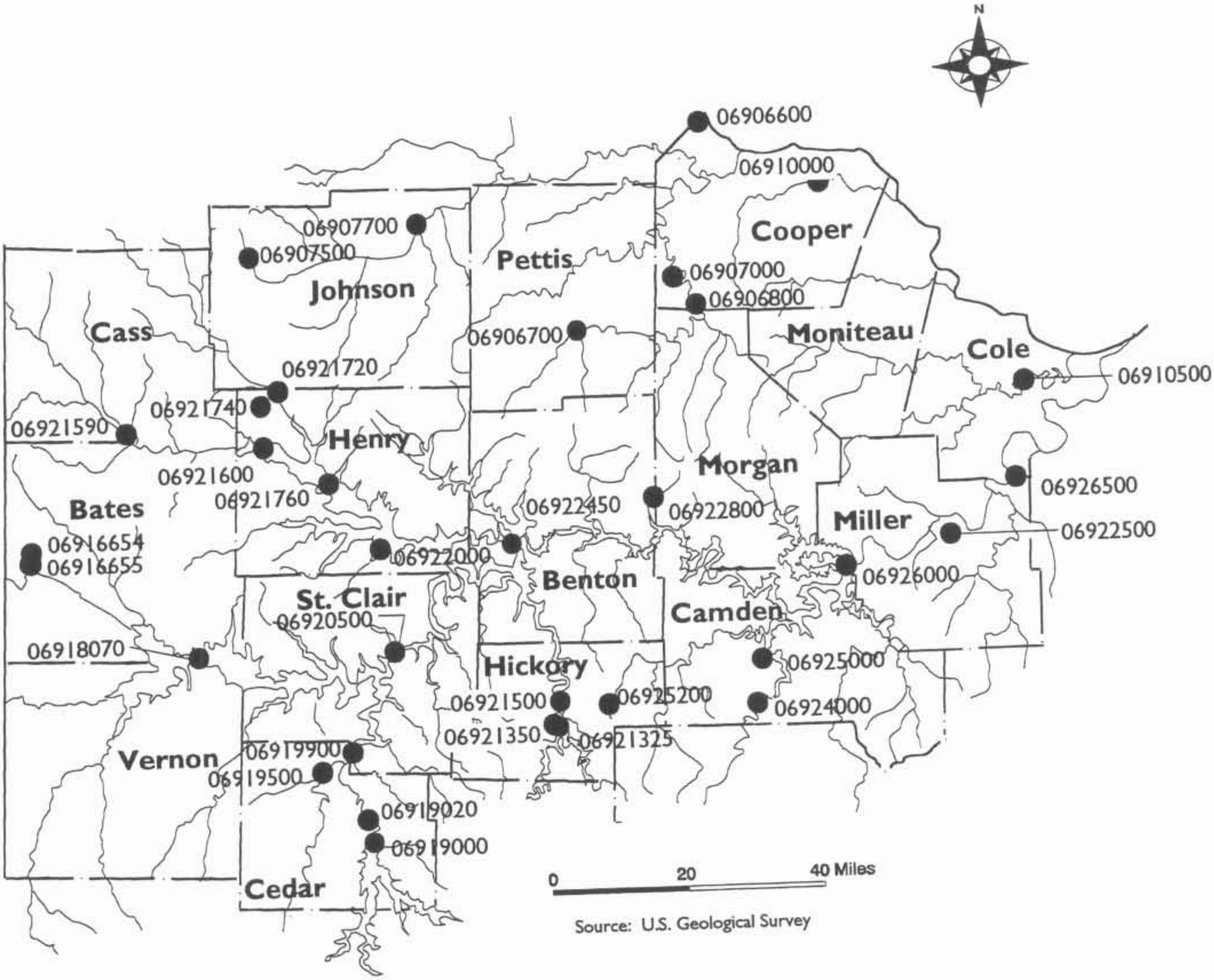


Source: U.S. Geological Survey

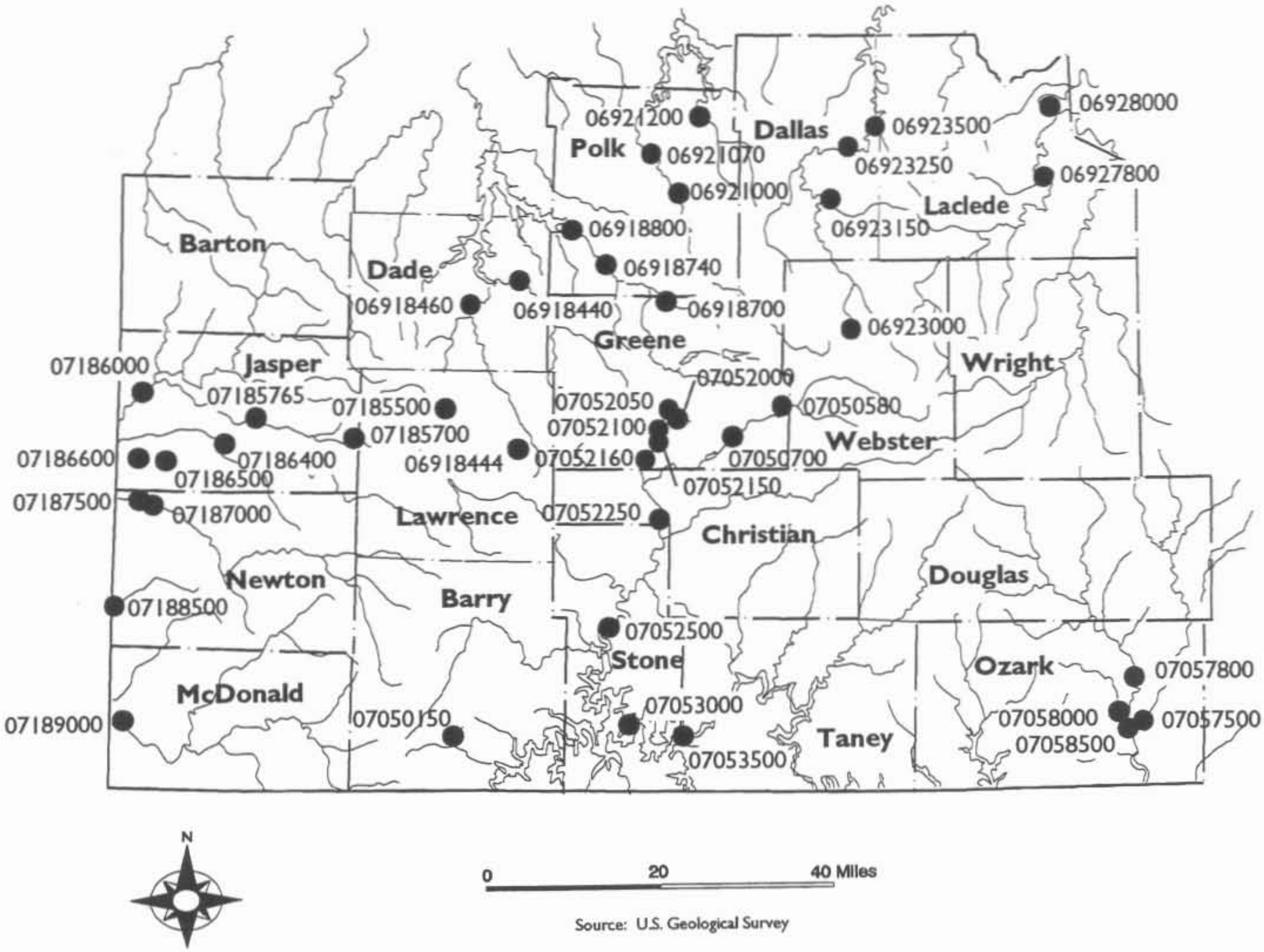
Northeastern Missouri



Westcentral Missouri

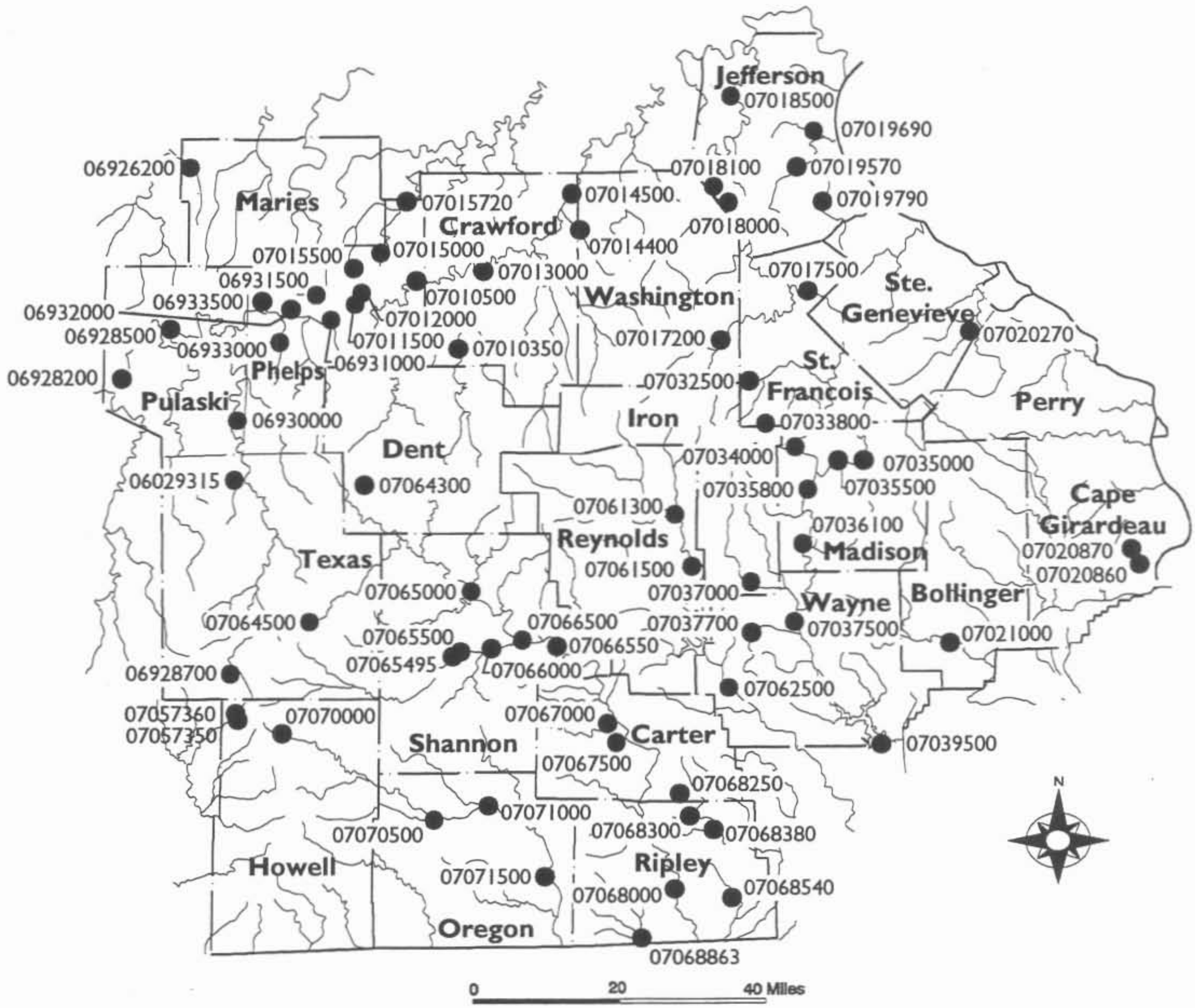


Southwestern Missouri



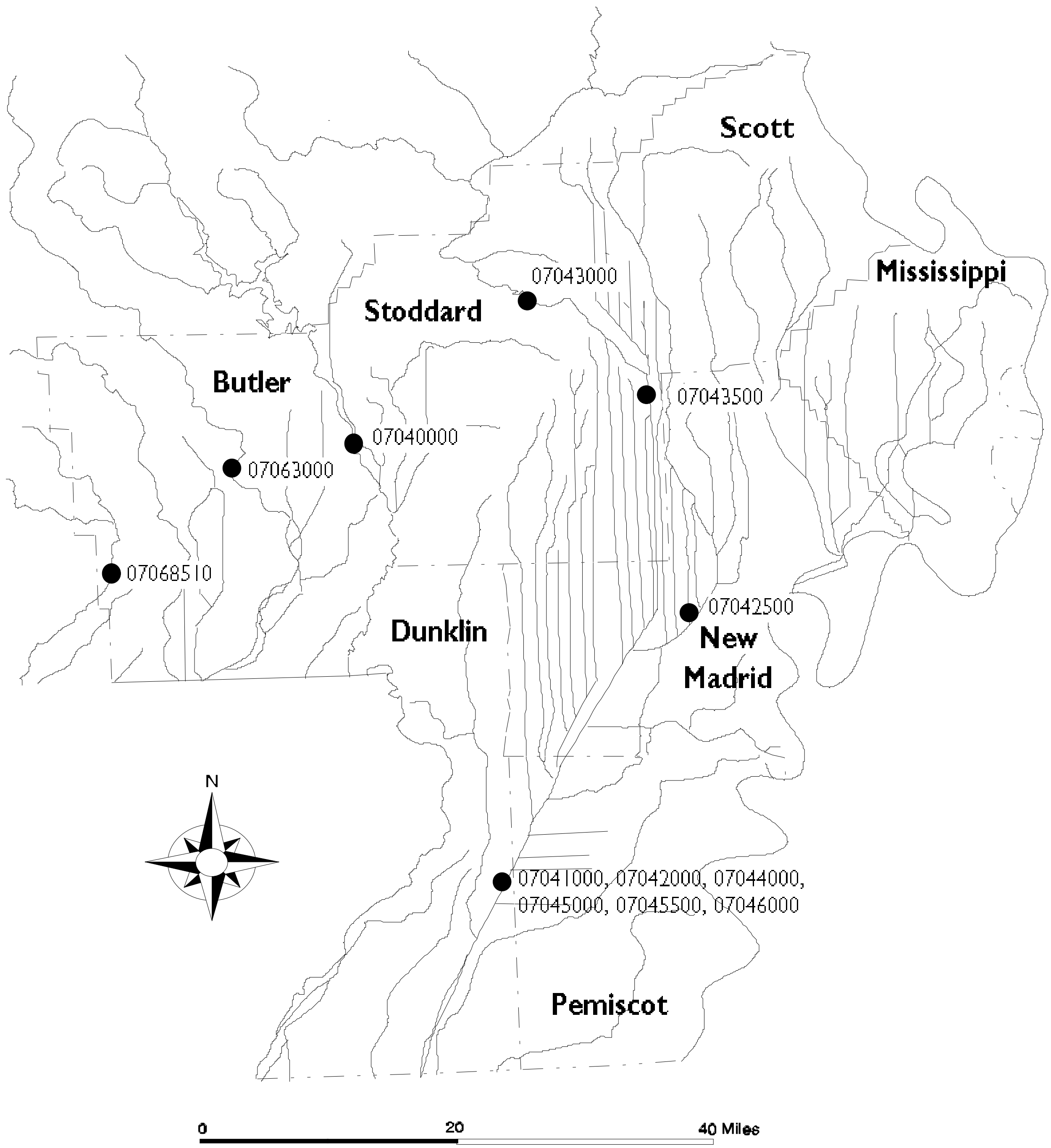
Source: U.S. Geological Survey

Southeastern Region



Source: U.S. Geological Survey

Bootheel Region



Source: U.S. Geological Survey

APPENDIX 7

LOSING STREAM REACHES IDENTIFIED IN MISSOURI (BY COUNTY)

NOTE: A stream reach not appearing on this list has not necessarily been determined to be "gaining." Many stream reaches have not been surveyed for losing characteristics.

(Source: DNR Losing Stream Reaches Database)

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Barry		
Browning Hollow	3	1
Calls Hollow	2	1
Calton Cr.	6.5	2
Capps Cr.	5	1
Clear Cr.	4	1
Dodge Hollow	3	1
Dog Hollow	3	1
Dry Hollow	7	1
Flat Cr	3	1
Gunter Hollow	6.5	2
Hudson Cr.	7	2
Joyce Cr.	4	2
Kelly Cr.	5	1
L. Flat Cr.	6	2
Ledgerwood Hollow	0.5	1
Poque Cr.	3	1
Prairie Run Hollow	5	1
S. Indian Cr.	2	1
Spring R.	2	1
Todd Hollow	3	1
Trib. to Capps Cr.	10	5
Trib. to Clear Cr.	5	6
Trib. to Dodge Hollow	4	3
Trib. to Flat Cr.	2.5	2
Trib. to Gunter Hollow	3.5	3
Trib. to Hudson Cr.	6	6
Trib. to Joyce Cr.	3.5	2
Trib. to L. Crane Cr.	14.5	12
Trib. to L. Flat Cr.	9	6
Trib. to Mill Cr.	1	2
Trib. to Poque Cr.	4	3
Trib. to Prairie Run H	1.5	1
Trib. to Woodward Cr.	1.5	2
Trib. to Zerbert Br.	2	1
Woodward Cr.	3	1
Zerbert Branch	4	1
Boone		
Bass Cr.	0.5	1
Bonne Femme Cr.	4	1
Fox Hollow Br.	1.5	1
Slate Cr.	1.5	1
Trib. to Bonne Femme C	1.5	1
Trib. to Clear Cr.	1	1
Trib. to Fowler Cr.	1.5	1
Trib. to Gans Cr.	1	1
Trib. to Jamerson Cr.	2	1
Trib. to L. Bonne Femm	1	1
Butler Cane Cr.	5	2
Callaway		
Trib. to Missouri R.	1	2
Camden		
Conns Cr.	3.5	1
Deberry Cr.	2	1
Forbes Br.	2.5	1
Libby Hollow	2	1
Mill Cr.	4.5	1
Murphy Cr.	1	1
Prairie Hollow	2	1
Racetrack Hollow	9.5	2

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Trib. to Linn Cr.	1	1
Trib. to Racetrack Hol	1.8	2
Carter		
Bear Spring Hollow	1	1
Big Barren Cr.	17.5	2
Big Brushy Cr.	3.5	1
Buchanan Valley	4	1
Carter Cr.	7	1
L. Pike Cr.	5	1
Middle Brushy Cr.	3.5	1
Middle Fk.	3	1
Right Fk.	2	1
Sweezie Hollow	0.5	1
Trib. to S. Fk. Big Br	2	1
Cedar		
Trib. to Snag Br.	0.5	1
Christian		
Carter Hollow	3	3
Drainage to sinkhole	2	3
Dry Crane Cr.	5	1
Elk Valley	5.5	2
Farmer Br.	2	1
Finley Cr.	3.5	2
Garrison Br.	0.7	2
Green Valley Cr.	4.5	1
Hog Cr.	2	1
Luce Br.	2.5	2
McCafferty Hollow	1.5	2
McCullah Hollow	7	1
Pedelo Cr.	0.5	1
Richwood Br.	0.5	1
Saunders Valley	1.5	1
Silver Lake Br.	2	1
Spout Spring Hollow	1.5	2
Spring Cr.	4	1
Squaw Run Cr.	3.5	1
Terrell Cr.	7.5	5
Tory Cr.	3	1
Trib. to Big Hollow	1.5	1
Trib. to E. Prong Goff	3.5	2
Trib. to Elk Valley	20.4	25
Trib. to Farmer Br.	1	1
Trib. to Finley Cr.	14.2	20
Trib. to Green Valley	7.5	9
Trib. to Hog Cr.	6.5	10
Trib. to Hunt Br.	1	1
Trib. to James R.	28.5	25
Trib. to Luce Br.	3.5	4
Trib. to McCafferty Ho	3.5	3
Trib. to McCullah Holl	2	2
Trib. to Mooney Hollow	0.5	1
Trib. to Parched Corn	2	3
Trib. to Parched Corn	7	5
Trib. to Pickerel Cr.	1.5	1
Trib. to Richwood Br.	1	1
Trib. to Spout Spring	1.5	3
Trib. to Spring Cr.	5	3
Trib. to Squaw Run Cr.	2.5	3
Trib. to Terrell Cr.	0.3	1
Trib. to W. Prong Goff	4	2
Trib. to Wilson Cr.	1	1
Trib. to sink to James	3.5	3
Trib.to Dry Crane Cr.	2	1
Turnback Cr.	10	2
Wolfden Cr.	1	1
Woods Fk.	2	1
Cooper		
Trib. to Clarks Fk.	1.5	1
Crawford		
Black Jack Cr.	4.5	2
Cherry Valley	8	1
Dry Cr.	11.5	1
Trib. to Cherry Valley	2	1
Trib. to Yadkin Cr.	4	1
Whittenburg Cr.	4	1
Dade		
Sinking Cr.	2.5	1
Dallas		
Fourmile Cr.	0.5	1
Dent		
Barren Fk.	9	1
Big Cr.	2.5	1
Black Oak Cr.	2	1
Dry Br.	3	1
Dry Fk.	27	2
Dry Valley Cr.	7	1
Finn Br.	4.5	1
Gladden Cr.	11	1
Gorden Hollow	2	1
Hodge Cr.	2.5	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Horse Cr.	5	1
Hyer Br.	1	1
L. Sinking Cr.	2	1
Meramec R.	8	1
Minning Haw Hollow	1.5	1
Norman Cr.	15	1
Orchard Mill Hollow	2	1
Pankey Br.	3	1
Pigeon Cr.	9	1
Rocky Pond Hollow	5	2
Roney Hollow	2	1
Standing Rock Cr.	5	1
Stone Hill Br.	4	1
Stringer Br.	2	1
Trib. to Dry Br.	3.5	1
Trib. to Dry Fk.	2	1
Trib. to Simmons Br.	1	1
Trib. to Spring Cr.	1	1
Douglas		
Browning Hollow	2.5	1
Brush Cr.	4	1
Bryant Cr.	8	1
Clifty Cr.	5.5	1
Prairie Cr.	2.5	1
Smith Hollow	4	1
Spring Cr.	12	1
Trib. to Prairie Cr.	0.8	1
Franklin		
Dry Cr.	1.5	1
Dry Cr. and trib.	1	1
Iron Hollow	2	1
Lollar Br.	1	1
Trib. to Boone Cr.	2	1
Trib. to Bourbeuse R.	0.8	1
Trib. to Dry Cr.	3.5	1
Trib. to Fiddle Cr.	1	1
Winsel Cr.	7	1
Greene		
Asher Cr.	0.5	1
Big Hollow	0.5	1
Broad Cr.	2	1
Davis Cr.	1.2	2
Drainage to sinkhole	3	2
Dry Br.	5	1
Fassnight Cr.	2	1
Hunt Br. and Farmer Br	5	1
Jordan Cr.	2	1
McElhaney Br.	2	1
Mooney Hollow	3.5	1
Mt. Pleasant Br.	2	1
Parched Corn Hollow	3	1
Pearson Cr.	1	1
Pickerel Cr.	8	2
Pond Cr.	3.5	2
Rainer Br.	2	1
S. Dry Sac R.	6	1
Sac R.	5	1
Sawyer Cr.	1	1
Shuyler Cr.	3.5	2
South Cr.	2.5	1
Spring Cr. and trib.	2	1
Sugar Cr.	1.5	1
Trib. to Broad Cr.	2	3
Trib. to Farmer Br.	1	1
Trib. to Hunt Br.	4.5	5
Trib. to James R.	24.9	24
Trib. to Jones Br.	1	2
Trib. to Jordan Cr.	2	1
Trib. to L. Sac R.	0.5	1
Trib. to Pearson Cr.	14.4	18
Trib. to Pickerel Cr.	2	1
Trib. to Sac R.	2	1
Trib. to Shuyler Cr.	2.5	3
Trib. to Turkey Cr.	0.2	1
Trib. to Turner Cr.	2	2
Trib. to Ward Br.	3.5	3
Trib. to Wilson Cr.	22.7	20
Trib. to Workman Br.	1	1
Turner Cr.	4	1
Unnamed perched stream	0.5	1
Ward Br.	4	2
Wilson Cr.	7	3
Workman Br.	0.5	1
Howell		
Bay Cr.	2.5	1
Bennetts R.	6	1
Big Greasy Cr.	3	1
Chapin Br.	3	1
Crooked Br.	5	1
Davis Cr.	2	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Dry Cr.	14	2
Eleven Point R.	32	1
Elk Cr.	4	1
Galloway Cr. and trib.	0.5	1
Gunters Valley	8	1
Horton Hollow	2	1
Howell Cr.	16	1
Jam Up Cr.	5	1
Kenaga Hollow	8	1
Kenyon Hollow	2.5	1
L. Greasy Cr.	5	1
Lee Hollow	6	1
Little Cr.	9	1
Lost Camp Cr.	12	1
Middle Fk.	10	1
Moss Hollow	4	1
Mustion Cr.	5.5	2
Myatt Cr.	13	1
N. Fk. Dry Cr.	3.5	1
Ray Br.	2.5	1
Spradlin Cr.	3	1
Spring Cr.	15.5	2
Tabor Cr.	15	2
Trib. to Dry Cr.	7	1
Trib. to Eleven Point	2.5	1
Trib. to Little Cr.	2	1
Trib. to Lost Camp Cr.	8	2
Trib. to Spring Cr.	4	1
Trib. to Tabor Cr.	2	1
Jackson		
Trib. to Blue Br.	0.2	1
Jasper		
Fidelity Br.	4	2
Grove Cr.	1	1
Short Cr.	1.5	1
Spring Br.	3	1
Trib. to Center Cr.	4.5	2
Trib. to Jenkins Cr.	1	1
Jefferson Antire Cr.	2	1
Bear Cr.	2	1
Bourne Cr.	2	1
Buck Cr.	1.5	1
Dulin Cr.	1	1
Glaize Cr.	7.5	2
Haverstick Cr.	1	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Heads Cr.	5	1
Hocum Hollow	1	1
Isum Cr.	1	1
L. Antire Cr.	4	2
McMullen Br.	1.5	1
Moss Hollow	2	1
Murril Br.	0.5	1
Prairie Hollow	2.5	1
Rock Cr.	1.2	1
Romaine Cr.	2	1
Scullbones Cr.	1	1
Trib. to Black Cr.	0.5	1
Trib. to Glaize Cr.	5.7	6
Trib. to Heads Cr.	3	3
Trib. to Hocum Hollow	1.5	1
Trib. to Meramec R.	1.5	2
Trib. to Mississippi R	2	2
Trib. to Moss Hollow	2	3
Trib. to Sandy Cr.	3.5	4
Williams Cr.	6.5	2
Laclede		
Bear Cr.	1.5	1
Bennett Spring Cr.	10.8	1
Dog Wood Cr.	2.5	1
Dousinbury Cr.	3.5	2
Dry Auglaize Cr.	25	1
Gasconade R.	26	1
Goodwin Hollow	20	1
Mill Cr.	5.5	2
Mountain Cr.	5.5	1
N. Cobb Cr.	14.5	3
Osage Fork	6	1
Pig Pen Hollow	1	1
Steins Cr.	2	1
Trib. to N. Cobb Cr.	2.5	1
Trib. to Woodward Holl	3.8	1
Woodward Hollow	6.8	1
Woolsey Cr.	10	1
Lawrence		
Browning Hollow	4	1
Douger Br.	2	1
Dry Hollow	10	2
Goose Cr.	3	1
Hemphill Br.	4.5	3
Hewlett Br.	4	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Hickory Hollow	3	2
Hillhouse Br.	3	1
Honey Cr.	9	1
Pruitt Br.	2.5	1
Trib. to Clear Cr.	3	1
Trib. to Crane Cr.	1.3	3
Trib. to Goose Cr.	2	1
Trib. to Hemphill Br.	4.5	3
Trib. to Hickory Hollo	0.5	1
Trib. to Honey Cr.	9	6
Trib. to L. Crane Cr.	0.2	1
Trib. to Spring R.	8.5	3
Trib. to Stahl Cr.	0.8	1
Maries		
Dry Fk.	11	1
Klein Br.	0.8	1
Mc Donald		
Bear Cr.	3	1
Beaver Br.	3.5	2
Big Sugar Cr.	1	1
Cave Spring Br.	1	1
Missouri Cr.	4	1
Sugar Fk.	1.5	1
Trib. to Elk R.	1	1
Trib. to Indian Cr.	1.5	1
Yarnell Br.	2	1
Newton		
Buffalo Cr.	4	1
Bullskin Cr.	2	1
Elm Spring Br.	4	1
Fivemile Cr.	1	1
Jones Cr.	2.5	1
L. Lost Cr.	4	1
Lost Cr.	2	1
Middle Indian Cr.	2	1
Rock Br.	2	1
Spring Cr.	1.5	1
Thurman Cr.	3	1
Trib. to Hickory Cr.	2	1
Unnamed trib.	6	2
Oregon		
Bussell Br.	5	1
Dry Cr.	9	
		1
Dry Prong	2	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
English Cr.	2.5	1
Frederick Cr.	26.5	2
Freeman Hollow	3	1
Greenbriar Hollow	4	1
L. Hurricane Cr.	4.5	1
Piney Cr.	15	1
Rover Br.	4	1
School House Hollow	3	1
Sitton Valley	4	1
Spring R.	2	1
Trib. to Bussell Cr.	1.5	1
Unnamed trib.	1.5	1
Warm Fork	6	1
Water Br.	2	1
Watered Fork	4	1
Whites Cr.	7	1
Osage		
Elk Cr.	4	1
Owens Cr.	7	2
Pointers Cr.	3	1
Unnamed trib.	6	2
Ozark		
Gardner Hollow	4	1
Smith Hollow	2	1
South Fk.	5.5	1
Thompson Hollow	3	1
Turkey Cr.	11	1
Unnamed trib.	9	3
Perry		
Trib. to Blue Spring B	1	1
Unnamed trib.	3	1
Phelps		
Bradford Br.	2	1
Corn Cr.	8	1
Deep Hollow	3	1
Hardester Hollow	2	1
L. Piney Cr.	10	1
Mill Cr.	1.5	1
Unnamed trib.	2	1
Pike		
Peno Cr.	1	1
Pulaski		
Burchard Hollow	1.5	1
Collie Hollow	7	1
Dry Br.	4	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Gillis Hollow	1	1
Roubidoux Cr.	17	1
Round Pound Hollow	3	1
Sawmill Hollow	3	1
Smith Br.	9	1
Trib. to Big Piney R.	2	1
Trib. to Gasconade R.	1	1
Unnamed trib.	4	3
Weeks Hollow	5	2
York Hollow	2.5	1
Ralls		
Jug Run	1.5	1
Reynolds		
Bee Fk.	8	2
Big Cr.	3.5	1
Dickens Valley	10	1
Dry Valley	10	1
Ellington Hollow	2	1
Harrison Valley	5	1
Kitchell Cr.	2	1
Logan Cr.	21	2
Sinking Cr.	14	1
Smalls Cr.	1.5	1
Tom's Cr.	5.5	1
Toms Cr.	1	1
Unnamed trib.	1	1
W. Fk. Huzzah Cr.	4	1
Ripley		
L. Barren Cr.	12	1
N. Fk. Buffalo Cr.	5	1
Shannon		
Bee Fork Cr.	7	1
Birch Cr.	13	2
Black Valley Cr.	6	1
Hurricane Cr.	15	1
Johnny Hollow	1	1
L. Hurricane Cr.	4.5	1
Pike Cr.	24	1
Pine Hollow	2	1
Spring Cr.	18	1
Sycamore Cr.	6	1
Unnamed trib.	8.5	3
Young Hollow	3.5	1
St. Charles		
Callaway Fk.	3.5	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
L. Femme Osage Cr.	0.5	1
Schote Cr.	1	1
Trib. to Callaway Cr.	4.5	3
Trib. to Dardenne Cr.	1	1
Trib. to Kraut Run	0.5	1
Trib. to L. Femme Osag	4.5	5
Trib. to Missouri R.	5	6
Trib. to Schote Cr.	0.7	1
Unnamed trib.	1	1
St. Francois		
Trib. to Big R.	0.2	1
St. Louis		
Bonhomme Cr.	0.7	1
Caulks Cr.	3.5	2
Fishpot Cr.	10	
		2
Hamilton Cr.	1	2
Keifer Cr.	3	1
Trib. to Bonhomme Cr.	2	2
Trib. to Caulks Cr.	1	1
Trib. to Fishpot Cr.	2	1
Trib. to Fox Cr.	2	1
Trib. to Hamilton Cr.	1	1
Trib. to Keifer Cr.	1	1
Trib. to Mississippi R	0.2	1
Trib. to Wildhorse Cr.	0.5	1
Ste. Genevieve		
Anderson Hollow	3	1
S. Fk. Saline Cr.	5	1
Stone		
Cave Spring Hollow	1.5	1
Crane Cr.	0.5	1
Devil Den Hollow	1.5	1
Dodge Hollow	1.5	1
Hilton Hollow	1.5	1
Horse Cr.	2	1
Indian Cr.	1.5	1
John Hollow	2	1
L. Crane Cr.	1.5	1
L. John Hollow	1.5	1
McCord Br.	6	1
Old Stillhouse Hollow	1	1
Pine Run	3	1
Rickman Spring Hollow	1.5	1
Right Hand Hollow	1	1
Schooner Cr.	0.5	1

STREAM	LOSING REACH LENGTH (MILES)	NUMBER OF LOSING REACHES
Smith Brown Hollow	2	1
Trib. to Crane Cr.	7.5	7
Trib. to Hilton Hollow	3.5	3
Trib. to Horse Cr.	0.5	1
Trib. to McCord Cr.	2.3	3
Trib. to McCullah Holl	2.5	3
Trib. to Old Stillhous	0.5	1
Trib. to Railey Cr.	9.3	7
Trib. to Spring Cr.	9	9
Trib. to W. Prong Goff	4	2
Trib. to Wheeler Br.	1	1
Unnamed Trib.	1.5	1
Unnamed trib.	4.8	3
W. Prong Goff Cr.	3.5	1
Wheeler Br.	2	1
Wilson Run	2.5	2
Taney		
Trib. to Silver Cr.	0.5	1
Trib. to Swan Cr.	1	2
Texas		
B. Paddy Cr.	3	1
Ball Ridge Cr.	5.5	1
Big Cr.	13	1
Brushy Cr.	2.5	1
Castro Valley	8	1
Dry Bone Cr.	1	1
Kelly Hollow	3	1
L. Paddy Cr.	1.5	1
Mooney Br.	2	1
Musgrave Hollow	1	1
S. Ashley Cr.	6	1
Spring Cr.	19	2
Spring Valley	29	1
Trib. to Piney Cr.	1.5	1
Van Zant Cr.	2.5	1
Warren		
Trib. to N.Fk. Charret	0.5	1
Wayne		
Barren Fk.	3	1
Otter Cr.	16	1
Pleasant Valley	2.5	1
Smoot Hollow	4	1
Unnamed Trib.	3	2
Webster		
Burks Hollow	2.5	1
Compton Br.	1.5	1
Davis Br.	5	2
Dry Cr.	0.5	1
Dry Fk. Panther Cr.	2.5	2
Greasy Cr.	0.5	1
L. Finley Cr.	0.5	1
Norman Br.	2	1
Panther Cr.	1	1
Peck Hollow	2.5	2
Pedelo Cr.	7.5	2
Sawyer Cr.	2	1
Terrel Br.	2	1
Trib. to Compton Br.	0.5	1
Trib. to Cry Fk. Panth	0.5	1
Trib. to Davis Br.	2.5	4
Trib. to Davis Cr.	1	1
Trib. to Dry Cr.	3.5	4
Trib. to Dry Fk. Panth	5.5	4
Trib. to Finley Cr.	0.3	1
Trib. to James River	2.8	5
Trib. to L. Finley Cr.	1.5	3
Trib. to N. Carolina Cr.	6	7
Trib. to Norman Br.	2	3
Trib. to Osage Fk.	1	2
Trib. to Panther Cr.	2	2
Trib. to Peck Hollow	1	1
Trib. to Pedelo Cr.	6	6
Trib. to Sawyer Cr.	5	7
Trib. to W. Wildcat Cr	1	2
Trib. to White Oak Hol	2.5	3
Unnamed Trib.	3	1
W. Wildcat Cr.	4	2
White Oak Cr.	1	1
White Oak Hollow	1	1
Wright		
Dry Cr.	7.5	1
Elk Cr.	4.5	1
Fox Cr.	24	2
Fry Cr. and Wolf Cr.	3	1
Prairie Hollow Cr.	5	2
Steins Cr.	8	1
Unnamed Trib.	3	1

APPENDIX 8

MISSOURI RIVER WATERBORNE COMMODITY TRANSPORT

MISSOURI RIVER, FORT BENTON, MONTANA TO THE MOUTH (CONSOLIDATED REPORT)

Section Included: Fort Benton, Montana, to the mouth of the Missouri River, 2073.2 miles.

Freight Traffic, 1994 (thousand tons)
(Source: U.S. Army Corps of Engineers, Water Resources Support Center, Waterborne Commerce of the United States, Calendar Year 1994 Part 2 - Waterways and Harbors Gulf Coast, Mississippi River System and Antilles, WRSC-WCUS-94-2.)

Commodity	Grand Total
TOTAL, ALL COMMODITIES	**8,501**
TOTAL PETROLEUM AND PETROLEUM PRODUCTS	**349**
Subtotal petroleum products	349
2340 asphalt, tar & pitch	349
TOTAL CHEMICALS AND RELATED PRODUCTS	**600**
Subtotal fertilizers	**565**
3110 nitrogenous fert.	277
3120 phosphatic fert.	11
3130 potassic fert.	44
3190 fert. & mixes not elsewhere classified	232
Subtotal other chemicals and related products	**35**
3220 alcohols	9
3273 ammonia	5
3274 sodium hydroxide	19
3275 inorg. elem., oxides, & halogen salts	1
TOTAL CRUDE MATERIALS, INEDIBLE EXCEPT FUELS	**6,750**
Subtotal soil, sand, gravel, rock and stone	**6,702**
4331 sand & gravel	6,144

4335 waterway improvement material	557
4338 soil & fill dirt	1
Subtotal iron ore and scrap	**17**
4410 iron ore	17
Subtotal marine shells	**1**
4515 marine shells	1
Subtotal non-ferrous ores and scrap	**3**
4670 manganese ore	3
Subtotal sulphur, clay, and salt	**4**
4782 clay & refrac. mat.	4
Subtotal other non-metal. min.	**22**
4900 non-metal. min. not elsewhere classified	22
TOTAL PRIMARY MANUFACTURED GOODS	**248**
Subtotal lime, cement and glass	**230**
5220 cement & concrete	230
Subtotal primary wood products	**5**
5540 primary wood prod.	5
TOTAL FOOD AND FARM PRODUCTS	**553**
Subtotal grain	**327**
6241 wheat	120
6344 corn	61
6447 sorghum grains	146
Subtotal oilseeds	**161**
6522 soybeans	152
6590 oilseeds not elsewhere classified	9
Subtotal processed grain and animal feed	**50**
6782 animal feed, prep.	50
Subtotal other agricultural products	**14**
6865 molasses	14
TOTAL ALL MANUFACTURED EQUIPMENT, MACHINERY AND PRODUCTS	**2**
7500 textile products	2

MISSOURI RIVER, FORT BENTON, MONTANA TO THE MOUTH (CONSOLIDATED REPORT)

Section Included: Fort Benton, Montana, to the mouth of the Missouri River, 2073.2 miles.

Comparative Statement of Traffic
(thousand tons)

Year	Total	Year	Total
1985	6,471	1990	5,841
1986	6,991	1991	5,729
1987	6,736	1992	5,783
1988	6,681	1993	5,631
1989	5,352	1994	8,501

APPENDIX 9

MISSISSIPPI RIVER WATERBORNE COMMODITY TRANSPORT

MISSISSIPPI RIVER, MINNEAPOLIS, MINNESOTA TO MOUTH OF PASSES (CONSOLIDATED REPORT)

Freight Traffic, 1994 (thousand tons)

(* These numbers do not add up in the source document; possibly because of significant digits and rounding.)

(Source: U.S. Army Corps of Engineers, Water Resources Support Center, Waterborne Commerce of the United States, Calendar Year 1994 Part 2 - Waterways and Harbors Gulf Coast, Mississippi River System and Antilles, WRSC-WCUS-94-2.)

Commodity	Grand Total
TOTAL, ALL COMMODITIES	**496,823**
TOTAL COAL	**65,360**
coal lignite	60,813
coal coke	4,547
TOTAL PETROLEUM AND PETROLEUM PRODUCTS	**139,431**
Subtotal crude petroleum	**61,110**
crude petroleum	61,110
Subtotal petroleum products	**78,322***
gasoline	19,819
kerosene	388
distillate fuel oil	12,326
residual fuel oil	19,578
lube oil and greases	3,974
petroleum jelly and waxes	58
naphtha and solvents	6,077
asphalt, tar and pitch	6,839

petroleum coke	5,058
liquid natural gas	3,408
petroleum products not elsewhere class.	798
TOTAL CHEMICALS AND RELATED PRODUCTS	**48,612**
Subtotal fertilizers	**17,072***
nitrogenous fertilizers	7,588
phosphatic fertilizers	778
potassic fertilizers	2,410
fertilizer & mixes nec	6,297
Subtotal other chemicals and related products	**31,539**
acyclic hydrocarbons	826
benzene & tolulene	2,560
other hydrocarbons	6,233
alcohols	4,344
carboxylic acids	411
nitrogen func. compounds	610
organo- inorganic compounds	24
organic compounds not elsewhere classified	942
sulphur (liquid)	5,468
sulphuric acid	835
ammonia	2,264
sodium hydroxide	4,058
inorg. elem., oxides, & halogen salts	1,247
metallic salts	574
inorganic chemicals not elsewhere class.	123
radioactive material	1
pigments & paints	10
coloring materials not elsewhere class.	1
medicines	5
perfumes & cleaners	13

plastics	71
pesticides	5
starches, gluten, glue	15
chemical additives	413
wood & resin chemicals	14
chemical products not elsewhere classified	472
TOTAL CRUDE MATERIALS, INEDIBLE EXCEPT FUELS	**63,497**
Subtotal forest products, wood and chips	**1,377**
rubber & gums	373
fuel wood	1
wood chips	329
wood in the rough	533
lumber	126
forest products not elsewhere classified	15
Subtotal pulp and waste paper	**555**
pulp & waste paper	555
Subtotal soil, sand, gravel, rock and stone	**32,973**
building stone	22
limestone	8,014
gypsum	535
phoshpate rock	6,077
sand & gravel	9,779
waterway improvement materials	8,523
soil & fill dirt	22
Subtotal iron ore and scrap	**9, 115**
iron ore	5,168
iron & steel scrap	3,947
Subtotal marine shells	**79**
marine shells	79

Subtotal non-ferrous ores and scrap	**9,421***
copper ore	38
aluminum ore	7,928
manganese ore	669
non-ferrous scrap	294
non-ferrous ores nec	493
Subtotal sulphur, clay and salt	**499**
sulphur, (dry)	1
clay & refrac. materials	498
Subtotal slag	**782**
slag	782
Subtotal other non-metallic minerals	**8,696**
non-metallic minerals not elsewhere class.	8,696
TOTAL primary manufactured goods	**32,908**
Subtotal paper products	**607***
newsprint	86
paper & paperboard	478
paper products not elsewhere classified	44
Subtotal lime, cement, glass	**7,936**
lime	326
cement & concrete	7,479
glass & glass products	18
miscellaneous mineral products	113
Subtotal primary iron and steel products	**21,066**
pig iron	5,872
ferro alloys	2,175
iron and steel primary forms	5,455
iron and steel plates & sheets	4,467
iron and steel bars & shapes	1,215
iron and steel pipe & tube	679
primary i&s not elsewhere classified	1,202

Subtotal primary non-ferrous metal products	**2,960***
copper	171
aluminum	1,235
smelted products not elsewhere classified	179
fab. metal products	1,373
Subtotal primary wood products	**339**
primary wood products	339
TOTAL FOOD AND FARM PRODUCTS	**145,899***
Subtotal fish	**51***
fish (not shellfish)	11
shellfish	39
Subtotal grain	**84,525***
wheat	13,535
corn	61,965
rice	2,630
barley & rye	217
oats	1,333
sorghum grains	4,846
Subtotal oilseeds	**33,883**
soybeans	31,440
oilseeds not elsewhere classified	2,443
Subtotal vegetable products	**2,936***
vegetables & products	2,850
vegetable oils	87
Subtotal processed grain and animal feed	**21,741**
wheat flour	57
grain mill products	410
hay & fodder	31
animal feed, prep.	21,243

Subtotal other agricultural products	**2,761**
meat, fresh, frozen	35
meat, prepared	3
dairy products	10
fish, prepared	0
tallow, animal oils	165
animals and products not elsewhere classified	3
fruit & nuts not elsewhere classified	1
fruit juices	1
sugar	1,017
molasses	790
coffee	153
cocoa beans	0
alcoholic beverages	9
groceries	0
water and ice	229
food products nec	279
tobacco & products	0
cotton	29
natural fibers not elsewhere classified	2
farm products not elsewhere classified	28
TOTAL ALL MANUFACTURED EQUIPMENT, MACHINERY AND PRODUCTS	**925**
machinery (not electric)	476
electrical machinery	12
vehicles and parts	33
aircraft and parts	0
ships and boats	17
ordnance & accessories	10
manufactured wood products	22
textile products	143

rubber and plastic products	137
empty containers	1
manufactured prod not elsewhere classified	73
TOTAL WASTE AND SCRAP NOT ELSEWHERE CLASS	**173**
waste and scrap not elsewhere classified	173
TOTAL UNKNOWN OR NOT ELSEWHERE CLASSIFIED	18
unknown or not elsewhere classified	18
	1,920,805

MISSISSIPPI RIVER, MINNEAPOLIS, MINNESOTA TO MOUTH OF PASSES (CONSOLIDATED REPORT)

Comparative Statement of Traffic
(thousand tons)

Year	Total	Year	Total
1985	383,964	1990	475,276
1986	399,944	1991	471,741
1987	425,005	1992	491,006
1988	441,546	1993	475,112
1989	462,736	1994	496,823

APPENDIX 10

AQUATIC FAUNAL COMMUNITY CLASSES OF MISSOURI

note: endangered species are shown in *italics*

(Source: *Aquatic Community Classification System for Missouri*, Missouri Department of Conservation.)

I. BIG RIVER

flood plains;	2-10 miles wide
channel gradient;	less than 9/10 feet per mile
channel prattern;	historically braided
flow regimen;	continuous strong flow, one or more flood events per year
substrates;	silt, sand, gravel

characteristic fish species;
silver lamprey, *lake sturgeon*, *pallid sturgeon*, alligator gar, threadfin shad, burbot, yellow bass, striped mullet, spottail shiner, silverband shiner, sturgeon chub, and sicklefin chub

typical fish species;
chestnut lamprey, shovelnose sturgeon, skipjack herring, goldeye, blue sucker, blue catfish, white bass, sauger, freshwater drum, *flathead chub*, silver chub, emerald shiner, river shiner, channel mimic shiner, and speckled chub

other typical species;
alligator snapping turtle, Mississippi map turtle, common snapping turtle and spiny softshell turtle

II. LOWLAND FAUNAL REGION

flood plains;	most of region at various geologic times has been flood plain creating extensive wetlands
channel gradient;	generally less than one foot per mile
channel prattern;	extensive drainage ditch system of relatively straight channels
flow regimen;	well-sustained base flows
substrates;	drainage ditches and streams contain mostly sand and gravel, wetlands contain mostly silt and organic debris

characteristic fish species;
spotted gar, brown bullhead, *cypress minnow*, ironcolor shiner, ribbon shiner, *taillight shiner*, *Sabine shiner*, weed shiner, blacktail shiner, pugnose minnow, lake chubsucker, *spring cavefish*, pirate perch, starhead topminnow, flier, banded pygmy sunfish, bantam sunfish, *swamp darter*, *harlequin darter*, *goldstripe darter*, cypress darter, saddleback darter, and dusky darter

typical fish species;
spotted sunfish, warmouth, bullhead minnow, mosquitofish, tadpole madtom, *crystal darter*, mud darter, bluntnose darter, and slough darter

characteristic amphibian and reptile species;
mole salamander, three-toed amphiuma, green tree frog, Illinois chorus frog, upland chorus frog, bronze frog, Mississippi

mud turtle, southern painted turtle, *western chicken turtle*, western mud shake, green water snake, and broad-banded water snake

characteristic crayfish;

dwarf crayfish, eastern digging crayfish, shield crayfish, *shrimp crayfish*, gray-speckled crayfish, red swamp crayfish, and vernal crayfish

characteristic mussel species;

Plectomerus dombeyana

III. OZARK FAUNAL REGION

flood plains	tend to be narrow with in steep valleys where local relief often exceeds 300 feet
channel gradient;	high, often exceeding 3 feet per mile
flow regimen;	base flows maintained by springs
substrates;	coarse gravel, rubble, boulders, and bedrock

characteristic fish species;

chain pickerel, river redhorse, rock bass, Ozark bass, credear sunfish, largescale stoneroller, silverjaw minow, bigeye chub, redspot chub, bluntface shiner, cardinal shiner, whitetail shiner, wedgespot shiner, Ozark minnow, Ozark shiner, duskystripe shiner, telescope shiner, spotfin shiner, steelcolor shiner, bleeding shiner, southern redbelly dace, eastern slim minnow, creek chubsucker, *Ozark cavefish*, southern cavefish, northern studfish, plains topminnow, northern brook lamprey, southern brook lamprey, least brook lamprey, American brook lamprey, streamline chub, Ozark madtom, mountain madtom, checkered madtom, *Neosho madtom*, greenside darter, rainbow darter, White River saddled darter, Current River saddled darter, barred fantail darter, golden fantail darter, yoke darter, least darter, *Niangua darter*, stippled darter, Current River orangethroat darter, Missouri saddled darter, banded darter, bluestripe darter, gilt darter, *longnose darter*, stargazing darter, mottled sculpin, Ozark sculpin, and banded sculpin

typical fish species;

northern hog sucker, black redhorse, shadow bass, smallmouth bass, hornyhead chub, bigeye shiner, striped shiner, rosyface shiner, garvel chub, slender madtom, and striped fantail darter

characteristic amphibian species;

hellbender, ringed salamander, spotted salamander, longtail salamander, darksided salamander, cave salamander, Oklahoma salamander, four-toed salamander, Ozark zigzag salamander, slimy salamander, southern redback salamander, grotto salamander, wood frog, and *yellow mud turtle*

characteristic crayfish;

Hubb's crayfish, Salem cave crayfish, freckled crayfish, bristly cave crayfish, coldwater crayfish, black banded crayfish, woodland crayfish, longpincered crayfish, golden crayfish, midget crayfish, *Mammoth Spring crayfish*, saddlebacked crayfish, Meek's crayfish, gapefingered crayfish, excavator crayfish, ringed crayfish, Ozark crayfish, Big Creek crayfish, spothanded crayfish, and St. Francis River crayfish

characteristic mussel species;

spectacle case, cylindrical paper shell, squawfoot, slipper shell, salamander shell, fluted shell, rabbit's foot, Ozark shell, bullhead, kidney-shell, western fan shell, Ellipse, Plea's mussel, scale shell, little purple, rainbow shell, little spectacle-case, Neosho mucket, Reeve's mussel, *pink mucket*, elephant's ear, snuff box, and Curtis' shell

IV. PRAIRIE FAUNAL REGION

channel prattern;	extensive meandering
flow regimen;	low base flow
substrates;	silt and sand

characteristic fish species;
mud minnow, brassy minnow, common shiner, bigmouth shiner, Topeka shiner, fathead minnow, plains killifish, trout-perch, and plains orangethroat darter

typical fish species;
common carp, river carp-sucker, quillback, white sucker, black bullhead, orange-spotted sunfish, red shiner, sand shiner, western redfin shiner, creek chub, suckermouth minnow and johnny darter

characteristic amphibian and reptile species;
Great plains narrowmouth toad, northern crawfish frog, northern leopard frog, *Illinois mud turtle*, and *Blanding's turtle*

common amphibian and reptile species;
smallmouth salamander, eastern tiger salamander, eastern American toad, Blanchard's cricket frog, western chorus frog, common snapping turtle, western painted turtle, red-eared slider, midland smooth softshell, blotched water snake, diamondback watersnake, northern water snake, and Graham's crayfish snake

characteristic crayfish;
papershell crayfish and grassland crayfish

common crayfish;
northern crayfish

characteristic mussel species;
warty-back mussel

common mussel species;
giant floater, white heel splitter, pistol grip, maple leaf, pimple-back, warty-back, three-ridge, fragile papershell, pink paper-shell, pink heel-splitter, fat mucket and pocketbook

APPENDIX 11

AQUATIC FAUNAL ENDANGERED OR EXTIRPATED SPECIES LIST (SEPTEMBER 1995)

note: listings in *italics* indicates species has been extirpated
(Source: *Rare and Endangered Species Checklist of Missouri*, September 1995, Missouri Department of Conservation, Natural Heritage Database.)

	Scientific name	Common name
FEDERALLY LISTED ENDANGERED SPECIES		
Mollusks		
	Epioblasma florentina curtisi	Curtis' pearlymussel
	Lampsilis abrupta	Pink mucket
	Lampsilis higginsi	Higgins' eye
	Potamilus capax	*Fat pocketbook*
	Quadrula fragosa	*Winged mapleleaf*
Fish		
	Scaphirhynchus albus	Pallid sturgeon
STATE LISTED ENDANGERED SPECIES		
Mollusks		
	Anodontoides ferussacianus	Cylindrical papershell
	Antrobia culveri	Tumbling creek cavesnail
	Elliptio crassidens	Elephant ear
	Fontigens antroecetes	A cave snail
	Fontigens proserpina	A cave snail
	Rusconaiaebena	Ebonyshell
	Obovaria jacksoniana	Southern hickorynut
	Quadrula cylindrica	Rabbitsfoot
	Simpsonaias ambigua	Salamander mussel
	Somatogyrus rosewateri	A snail
Crustaceans		
	Orconectes lancifer	Shrimp crayfish
	Orconectes marchandi	Mammoth spring crayfish
	Orconectes meeki	Meek's crayfish

Fish

Acipenser fulvescens	Lake sturgeon
Amblyopsis rosae	Ozark cavefish
Chologaster agassizi	Spring cavefish
Crystallaria asprella	Crystal darter
Etheostoma fusiforme	Swamp darter
Etheostoma histrio	Harlequin darter
Etheostoma nianguae	Niangua darter
Etheostoma parvipinne	Goldstripe darter
Etheostoma whipplei	Redfin darter
Fundulus chrysotus	*Golden topminnow*
Hybognathus hayi	Cypress minnow
Notropis amnis	*Pallid shiner*
Notropis maculatus	Taillight shiner
Notropis sabinae	Sabine shiner
Noturus eleutherus	Mountain madtom
Noturus placidus	Neosho madtom
Percina nasuta	Longnose darter
Platygobio gracilis	Flathead chub
Umbra limi	Central mudminnow

Reptiles

Deirochelys reticularia miaria	Western chicken turtle
Emydoidea blandingii	Blanding's turtle
Kinosternon flavescens flavescens	Yellow mud turtle
Kinosternon flavescens spooneri	Illinois mud turtle
Nerodia cyclopion	*Mississippi green water snake*